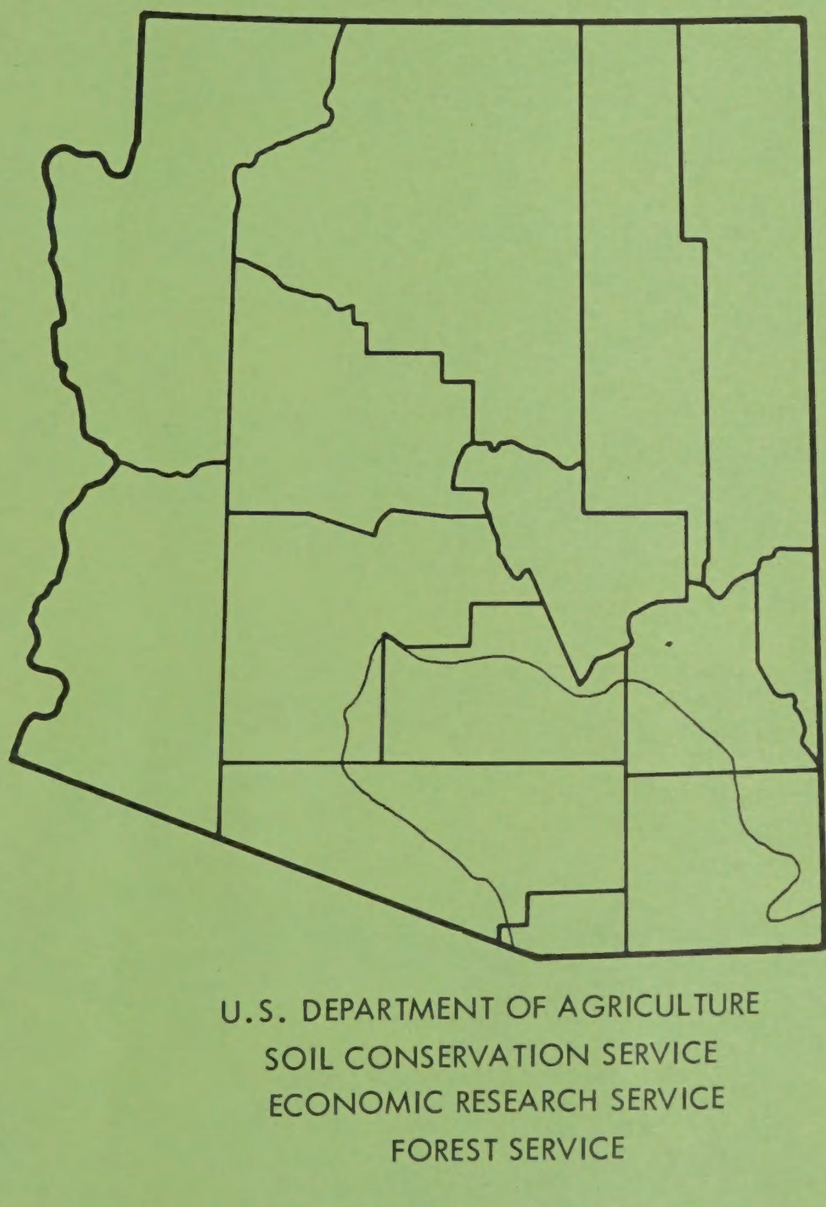
SANTA CRUZ - SAN PEDRO RIVER BASIN

ARIZONA

RESOURCE INVENTORY



U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
ECONOMIC RESEARCH SERVICE
FOREST SERVICE

In Cooperation with the

ARIZONA WATER COMMISSION

AUGUST 1977

USDA-SCS-PORTLAND, OR. 1978

SANTA CRUZ - SAN PEDRO RIVER BASIN
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This document was prepared pursuant to Section 6 of the Watershed Protection and Flood Prevention Act (Public Law 566, 83rd Congress, 68 Stat. 66, as amended and supplemented). It presents a detailed inventory of water and related land resources of the Santa Cruz-San Pedro River Basins, Arizona. This data served as the information base for preparation of a companion document, titled MAIN REPORT, SANTA CRUZ-SAN PEDRO RIVER BASINS, ARIZONA, U. S. Department of Agriculture, August 1977.

Prepared By

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CHAPTER 1

INTRODUCTION

LOCATION, SIZE, AND BOUNDARIES OF STUDY AREA

The Santa Cruz-San Pedro River Basins study area is located in southeastern Arizona. It includes 16,501 square miles located in parts of Pima, Cochise, Pinal, Santa Cruz, Graham, and Maricopa Counties (see Location Map). The boundaries of the study area are determined by the drainage areas of the Santa Cruz River, San Pedro River, Willcox Playa, Whitewater Draw, San Bernardino Valley, and those small tributaries which flow into the Gila River from the south and lie between the mouths of the Santa Cruz and San Pedro Rivers. The New Mexico State boundary and the Republic of Mexico National Boundary form the boundaries where drainage areas extend outside of Arizona. These portions outside the state were excluded from the study area. This included 1,200 square miles in the Republic of Mexico and 30 square miles in the State of New Mexico.

The Santa Cruz River heads in the Patagonia and Huachuca Mountains in Arizona and then drains south into Mexico. The river changes direction in Mexico and re-enters Arizona east of Nogales. It flows northwestward across Santa Cruz, Pima, and Pinal Counties and joins the Gila River about 12 miles southwest of Phoenix.

The San Pedro River heads in the Sierra Mariquita and Sierra De Los Ajos about 20 miles south of the United States-Mexico border. The river flows in a northerly direction across western Cochise County and eastern Pinal County and joins the Gila River about 80 miles southeast of Phoenix, The Gila River flows into the Colorado River about 130 miles west of the study area.

Whitewater Draw (Agua Prieta River in Mexico) is the northernmost tributary to Mexico's Yaqui River. Flows originate in the southern parts of the Chiricahua, Pedregosa, and Dragoon Mountains and drain in a southerly direction through the Sulpher Springs Valley and into Mexico.

The San Bernardino Valley lies in the extreme southeastern corner of the study area. The valley is drained by Black Draw which flows south into Mexico.

The Willcox Playa is a closed basin located in Cochise County. The playa is the termination point of drainages from the northern portion of the Sulphur Springs Valley and from mountain ranges that surround the playa.

PURPOSE AND SCOPE

This inventory is concerned with resource availability, use, quality,

problems, and needs. A companion document titled Main Report Santa Cruz-San Pedro River Basin, August 1977, by the Arizona Water Commission and USDA presents alternative plans formulated to maximize national economic development and emphasize environmental quality. This inventory serves as the base for preparation of the Main Report.

The study has been closely coordinated with the state agencies. The Arizona Water Commission was designated by the Governor as contact agency and principal cooperator for the state in this activity. The study is complimentary to the Commission's comprehensive water and related land planning activities.

The Arizona-U.S. Department of Agriculture (USDA) study serves three objectives: (1) identifying and evaluating alternative solutions to water and related land problems through eligible projects and programs of USDA, (2) developing data and findings for consideration in the Water Commission's state water planning activities, and (3) providing data in support of negotiations with Mexico concerning division of international waters. Although emphasis is placed on USDA projects and programs, opportunities for other agency projects and programs will be pointed out where needed.

The study will assist the Department of Agriculture in making the most effective use of its limited resources in the administration of Departmental programs and projects. It will serve also as a guide in coordinating related water and land resource activities of local, state, and other federal agencies. Basic data developed during the course of the study will be available to expedite further implementation studies of USDA as well as any studies by other agencies.

This area was recommended by the State for study because of the critical water and related land resource problems. Although the average annual surface water yield is quite low, much of the cropland and a major portion of the urban area is subject to extensive flooding. Sediment derived from upstream areas causes extensive damage to downstream areas. These conditions, along with planned and anticipated development and growth, marked this as an area requiring early comprehensive investigation.

The data presented in this inventory will be useful in making general appraisals of future water, land, and plant resource problems and development potentials and will serve as a base for subsequent planning. The USDA and the Arizona Water Commission cooperated to assure comprehensive investigation of water and related land resource problems and needs and to avoid duplication of effort. Use was made of resource data developed by other agencies and organizations.

AUTHORITY FOR STUDY

Responding to the June 24, 1969 request by the Governor of Arizona, the U.S. Department of Agriculture (USDA) authorized a comprehensive water resources planning study of the Santa Cruz-San Pedro River Basins in Arizona, in cooperation with the principal state water agency, which

was then the Interstate Stream Commission and is now the Arizona Water Commission. Participation by the USDA was authorized in July 1970, under provisions of Section 6 of the Watershed Protection and Flood prevention Act (Public Law 566, 83rd Congress, 68 Stat. 666, as amended). On November 11, 1971, the Governor of Arizona requested that the original area of study be enlarged to include the drainage areas of Whitewater Draw and the Willcox Playa. The USDA agencies were given authority to include the additional area for study on December 9, 1971.

The Statutes as revised in April 1971 for the State of Arizona vest in the Arizona Water Commission certain powers, jurisdiction, and authorities. Relevent to cooperative river basin studies, the revised Arizona statutes give authority to:

1. Prosecute and defend all rights, claims and privileges of the state respecting interstate streams.
2. Formulate plans and develop programs for the practical and economical development, management, conservation and use of the watersheds and waters of the state.
3. Initiate and participate in conferences, conventions or hearings, including, but not limited to, congressional hearings, court hearings, commission hearings or other competent judicial or quasu-judicial departments, agencies or organizations, and negotiate and cooperate with agencies of the United States, or of any state or government and represent the state concerning matters within the commission's jurisdiction,
4. Apply for and hold permits and licenses from the United States or any agency thereof for reservoirs, dam sites and right of ways.
5. Investigate works, plans or proposals pertaining to waters of the state, including management of watersheds, and acquire, preserve, publish and disseminate information relating thereto which the commission deems advisable.
6. Receive and review all reports, proposed contracts and agreements from and with the United States or any agency thereof, other states, governments or representatives thereof and recommend to the governor and the legislature action to be taken on such reports, proposed contracts and agreements, and in the case of reports to take action on such reports where authorized by law, and review and coordinate the preparation of formal comments of the state on both the preliminary and final reports relating to water resource development of the Chief of Engineers, Department of the Army, the Secretary of the Interior, and the Secretary of Agriculture, as provided for in the Flood Control Act of 1944 (58 Stat. 887, 33 U.S.C. 701-1).
7. Collect and investigate information upon and prepare and devise means and plans for the development, conservation, and utilization of all waterways, watersheds, subterranean waters, groundwater basins and water resources in the state and of all matters and subjects related thereto, including irrigation, drainage, water quality maintenance, regulation of flow, diversion of running streams adapted for development in cooperation with the United States or by the state independently, flood control,

utilization of water power, prevention of soil waste, storage, conservation and development of water for every useful purpose.

8. Measure, survey and investigate the water resources of the state and their potential development and may cooperate and contract with agencies of the United States for such purposes. The commission shall maintain a permanent public depository for existing and future records of stream flow, groundwater levels and water quality and other data relating to water resources of the state.
9. Recommend to the administrative heads of agencies, boards and commissions of the state, and the political subdivisions thereof, regulations to promote and protect the rights and interests of the state and its inhabitants in any matter relating to the waters of the state.

USDA AGENCIES PARTICIPATING

The study was made by representatives of the Soil Conservation Service, Economic Research Service, and Forest Service, USDA. The study was carried out in accordance with assigned responsibilities and coordinated through the Washington Advisory Committee and the Field Advisory Committee.

SPONSORING AND COOPERATING AGENCIES

The State of Arizona, by means of several related agencies, assists local people and their organizations in the conservation, development, and management of water and related land resources through Federal-state-local cooperation; and through the planning and coordination of projects and programs providing such assistance. The Arizona Water Commission was designated as the lead agency for cooperation in this activity because of the complementary relationship of the river basin study to the other on-going comprehensive water and related land resource planning activities in which the Commission is involved.

The Arizona Water Commission had overall state responsibility for coordination with other local, state, and federal agencies.

Many federal, state, and local organizations have contributed to the study by providing counsel and information and by participating in public meetings. Their cooperation and assistance is acknowledged. Significant contributions were made by the following:

Local

Counties
Irrigation Districts
Irrigation and Drainage Districts
Municipalities
Natural Resource Conservation Districts

Private

Defenders of Wildlife
Smithsonian Institution

State

Arizona Bureau of Mines
Arizona Environmental Planning Commission
Arizona Game and Fish Department
Arizona Outdoor Recreation Coordinating Commission
Arizona State Department of Health
Arizona State Land Department
Arizona State Parks Board
Arizona State University
Arizona Water Commission
Cooperative Extension Service
Office of Economic Planning and Development
University of Arizona

Federal

U.S. Department of Agriculture

- Agricultural Research Service
- Agricultural Stabilization and Conservation Service
- Economic Research Service
- Farmers Home Administration
- Federal Extension Service
- Forest Service
- Rural Electrification Administration
- Soil Conservation Service
- Statistical Reporting Service

U.S. Department of the Army

- Corps of Engineers
- Fort Huachuca Military Reservation

U.S. Department of Commerce

- Bureau of the Census
- National Weather Service

U.S. Department of the Interior

- Bureau of Indian Affairs
- Bureau of Land Management
- Bureau of Reclamation
- Fish and Wildlife Service
- Geological Survey

U.S. Department of State

International Boundary and Water Commission

U.S. Department of Transportation

Federal Highway Administration

Independent Federal

National Science Foundation
Kitt Peak National Observatory

U.S. Department of the Air Force

CHAPTER 2

RESOURCE AVAILABILITY AND QUALITY

CLIMATE

The arid, warm, and temperate climate of the study area is favorable for irrigated agriculture and light industry. The climate also makes the region attractive as a tourist area and retirement community location.

Precipitation

Mean annual precipitation is between 8 and 12 inches in the valleys and plains and from 16 to 20 inches in the habitable parts of the mountains. In the higher mountain regions, representing less than one percent of the study area, the average annual precipitation is more than 30 inches (see Figure 1). Almost half of the total annual precipitation falls during July and August (Figure 2). A second wet season extends from December through the middle of March. The driest season is during May and June.

The moisture for the summer precipitation comes from the Gulf of Mexico and the Gulf of California. This moisture generally falls in the form of local thundershowers. Such storms cover comparatively small areas and usually have a duration of less than one hour. Some thunderstorms are intense and result in rapid runoff. Although such storms usually occur separately, they can occur in conjunction with general storms.

Occasionally, tropical storms move into the study area from the Gulf of Mexico or Pacific Ocean. These storms, which generally occur in July, August, or September, often result in heavy rainfall over large areas for periods of up to 24 hours. Once the heavy rainfall has ended, showers may continue intermittently for as long as three days.

Rainfall during the winter is a result of frontal activities which usually cause precipitation over a large portion of the study area. Winter storms are typically less intense than summer thunderstorms but are of longer duration, often lasting several days. Above the 4,000-foot level, winter precipitation is frequently in the form of snow. Higher elevations such as Mount Graham and Mount Lemmon have had snow accumulations of more than six feet.

Temperature

The distribution of the average January and July temperatures over the study area are shown in Figures 3 and 4. In both months, there are moderate variations of temperature across the area. These variations result mainly from differences in elevation, although latitude also plays a part.

Mean minimum temperatures in January are near freezing or below over practically the entire desert floor and valley slopes. The mean minimum January temperatures range from 32.7 degrees Fahrenheit at Casa Grande to

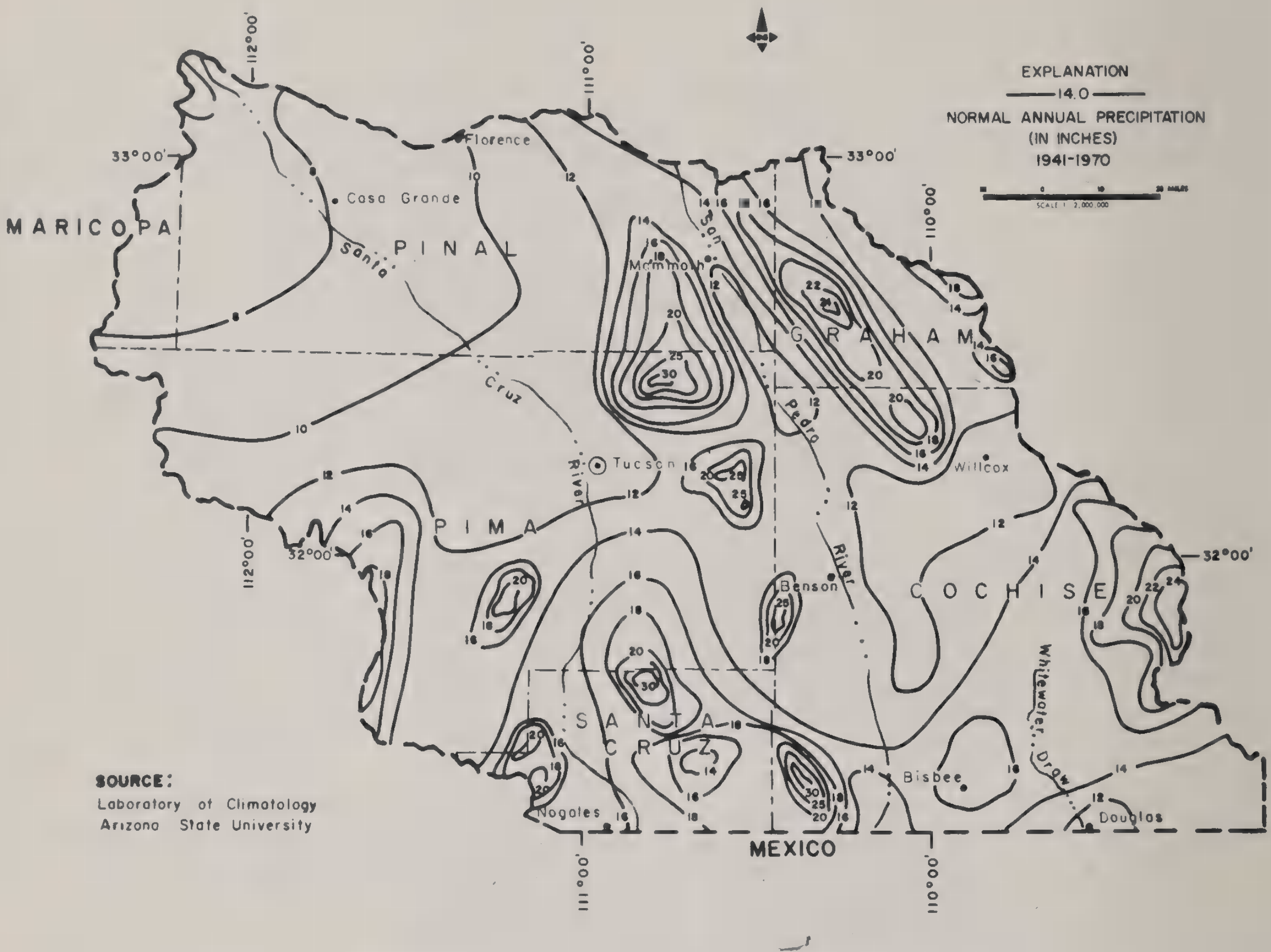


FIGURE 1 - Normal Annual Precipitation in the Santa Cruz-San Pedro River Basins

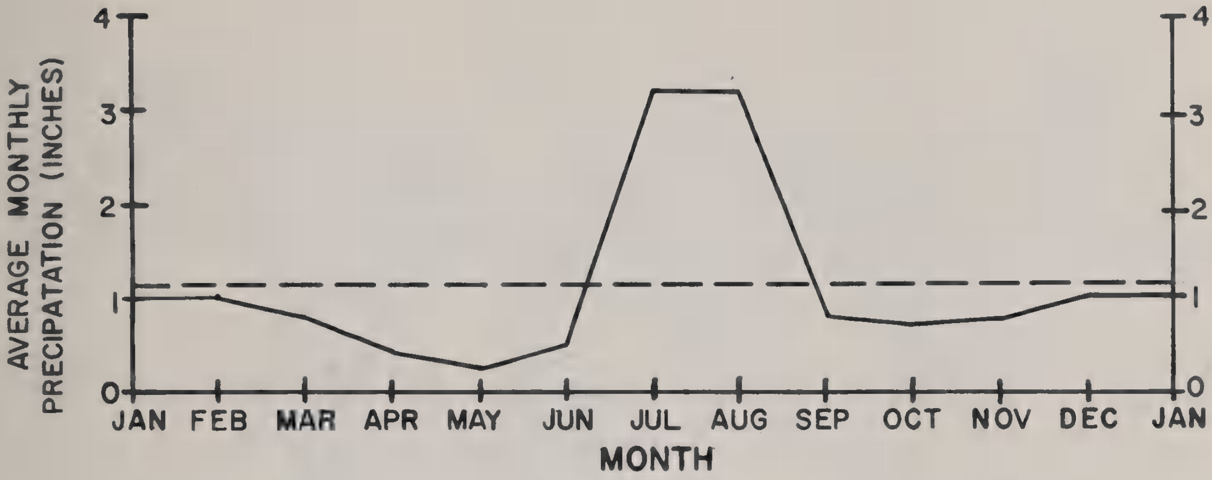


FIGURE 2 - Average Variation of Mean Monthly Precipitation in the Santa Cruz-San Pédro River Basins. Horizontal dashed line superimposed on curve indicates the average twelve monthly values. (Arizona Climate, C.R. Green and W. D. Sellars, 1964, page 10.)

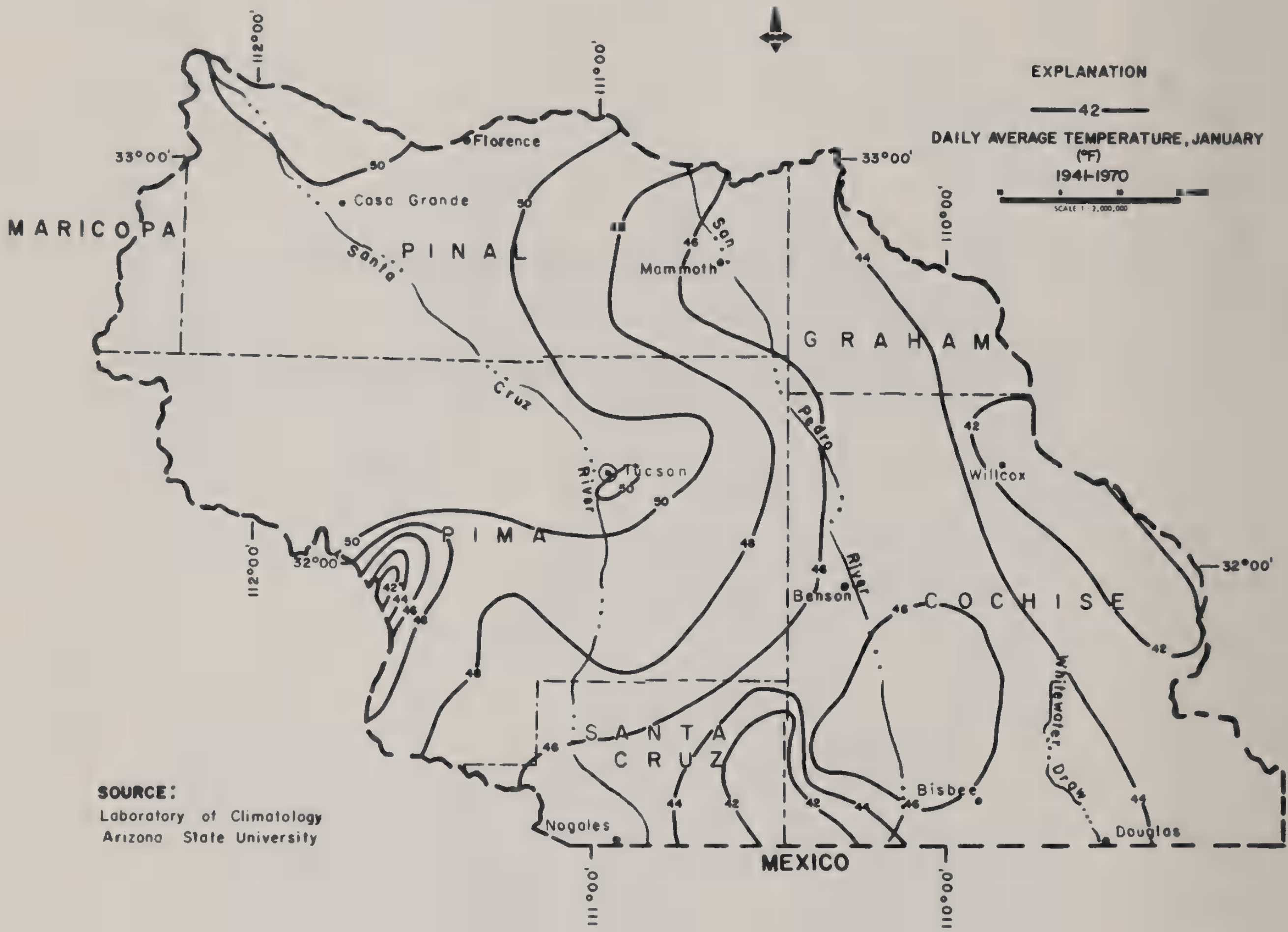


FIGURE 3 - Daily Average Temperature in January (^{O}F) in the Santa Cruz-San Pedro River Basins

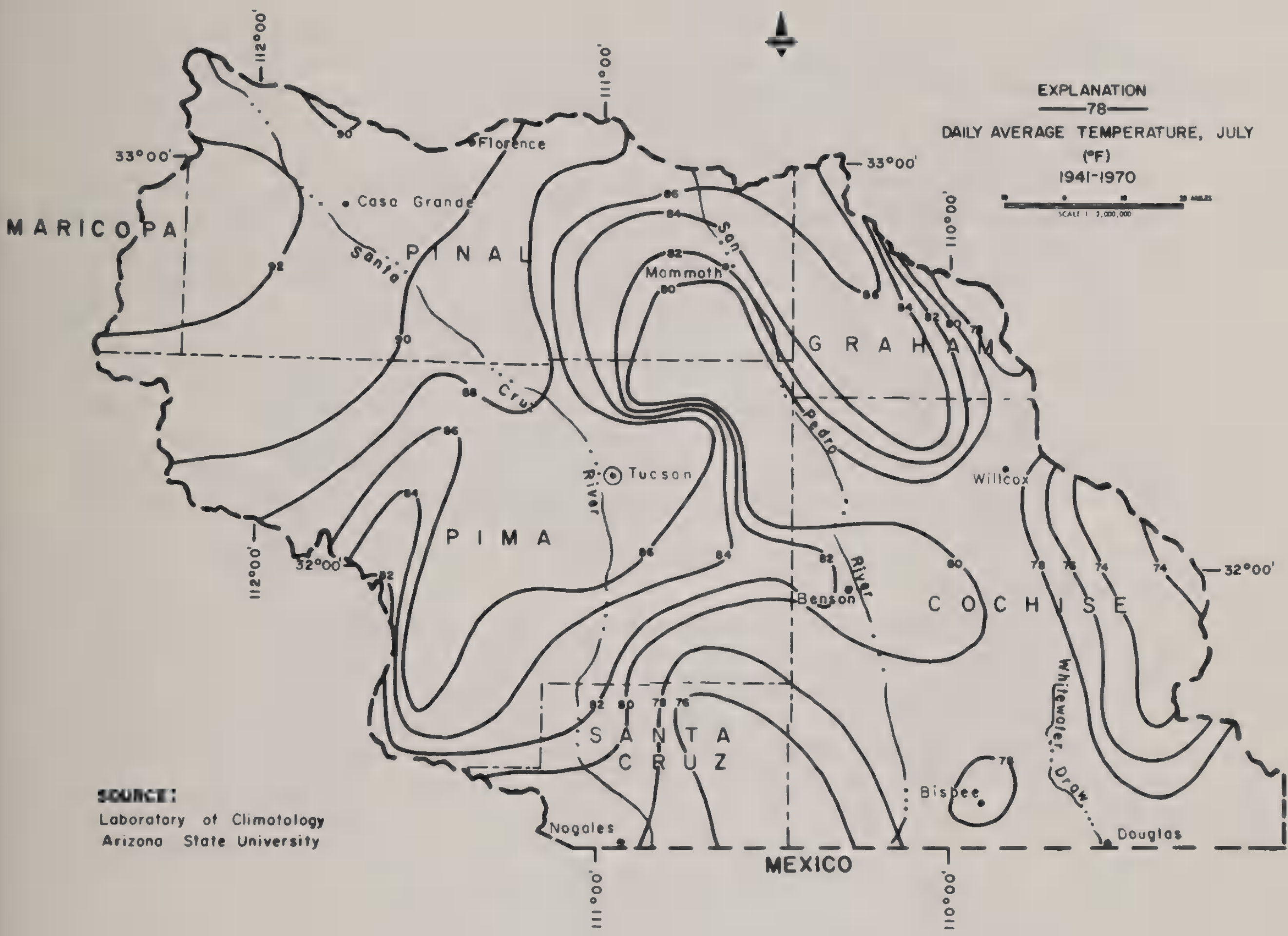


FIGURE 4 - Daily Average Temperature in July (°F) in the
Santa Cruz-San Pedro River Basins.

a low of 25 degrees at Willcox. However, extreme January temeratures of 17 degrees Fahrenheit and minus one degree have been recorded at these two locations, respectively.

The mean high July temperatures range from 105 degrees Fahrenheit in the valleys and plains to the upper 80's in the generally habitable parts of the mountains. The maximum extreme July temperature recorded in the study area was 122 degrees Fahrenheit at Casa Grande.

Not only is there a large fluctuation between summer and winter temperatures; but because of low moisture characteristics, intense surface heating occurs during the day, and radiational cooling is evident at night. This process produces a large diurnal temperature range, averaging 30 degrees and sometimes exceeding 40 degrees.

Few locations in Arizona have comfortable temperatures all year. However, one of the most comfortable parts of the State is located in the hill country in the southern portion of the study area. Sierra Vista, Bisbee, Ruby, Tombstone, and Canelo have especially mild climates, and many retirement communities are being developed in the vicinity.

Evaporation

The combination of high temperatures and low humidity causes high rates of evaporation and transpiration within the study area. In the valleys and plains where the human need for water is greatest, there is the least amount of precipitation; and the potential for evapo-transpiration is greatest. Mean annual lake evaporation rates vary from about 64 inches in the Willcox area to 72 inches on the western edge of the study area. (See Figure 5).

Length of Growing Season

The length of growing season ranges widely in the study area and depends on the local elevation and on the nature of the surrounding terrain. Based on the 32-degree threshold, the growing season ranges from about 180 days in the Willcox area to 300 days on the western edge of the study area (see Figure 6). Therefore, the growing season is adequate for a broad range of crops; and in some localities, double cropping is occurring.

Wind

Wind patterns throughout the entire study area are greatly affected by the slopes and character of the terrain. If no large-scale weather disturbances are present, wind will generally blow upslope or up-valley during the hotter part of the day and downslope and down-valley at night. The change of direction is induced by more rapid nighttime radiational cooling of the air overlying the mountain slopes as compared to the rate of cooling over the valleys. A good example of this type of air circulation occurs at Tucson. The wind blows up-valley from the west and northwest during the day and down-valley from the southeast at night and in the early morning hours.

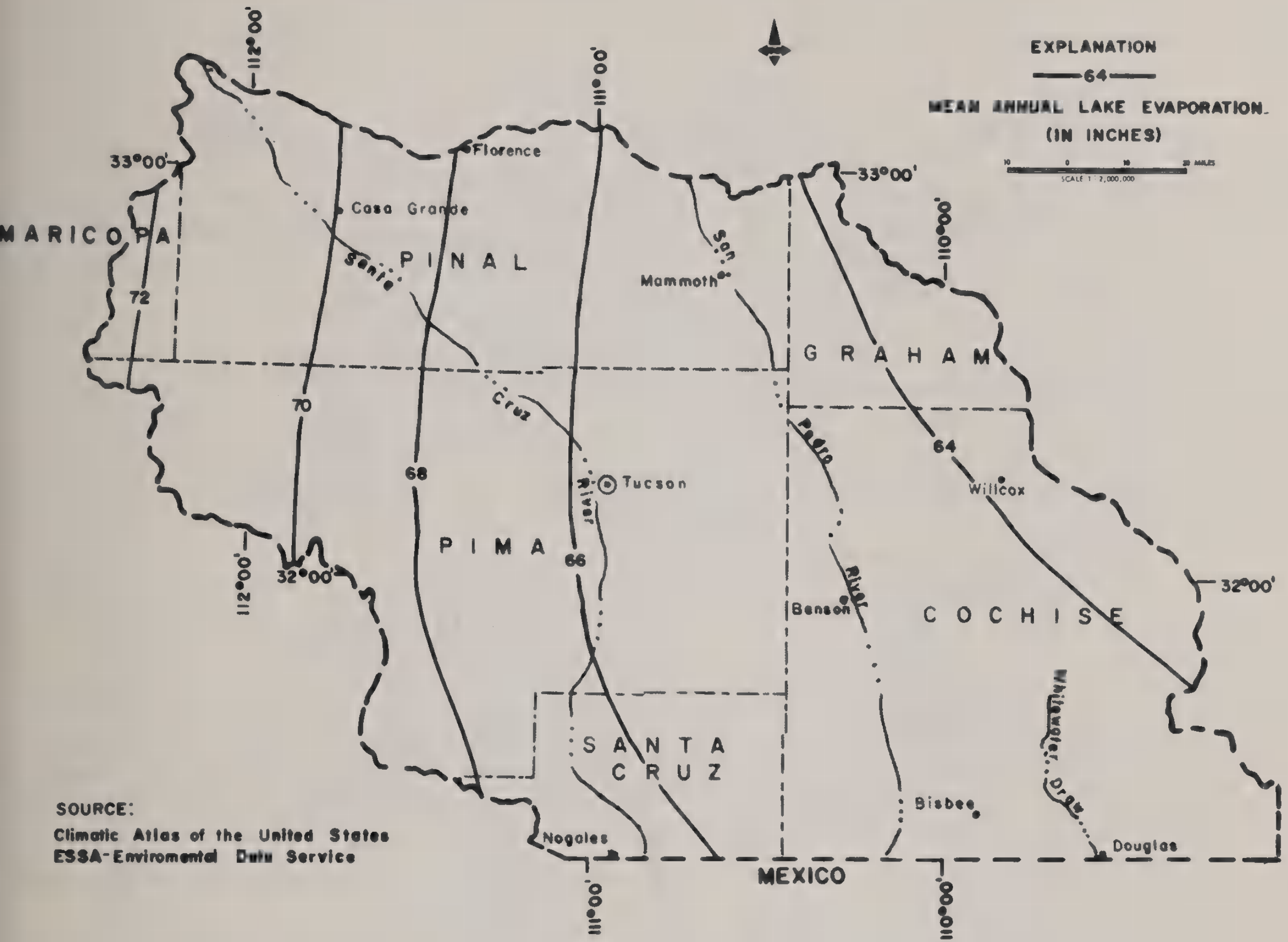


FIGURE 5 - Mean Annual Lake Evaporation (Inches) in the Santa Cruz-San Pedro River Basins.

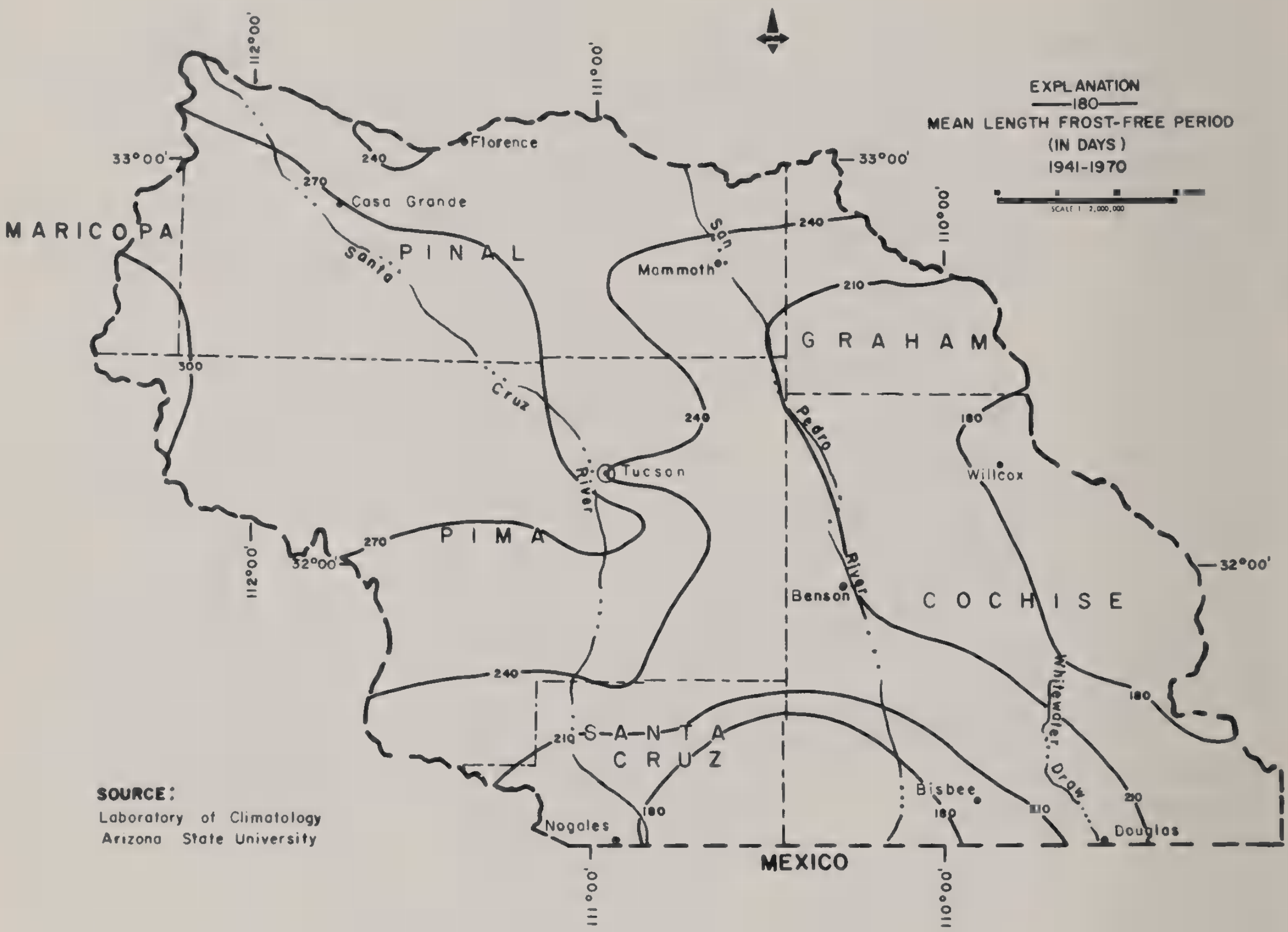


FIGURE 6 - Mean Length of Frost-Free Period (Days) Between Last $32^{O}F$ Temperature in Spring and First $32^{O}F$ Temperature in Autumn in the Santa Cruz-San Pedro River Basins.

Wind speeds at Tucson are generally less than 10 miles per hour. However, maximum velocities near 60 miles per hour have been recorded during intense thunderstorms. The direction of wind associated with thunderstorms is generally of a random nature.

Relative Humidity

Relative humidity, the moisture content in the air, is expressed as the percent of the amount which the air could hold. Wide daily and seasonal variations occur within the study area. Relative humidity reaches its peak in August, has moderate peaks during December through February, and declines to the low point in May and June.

The June, July, and August, the temperature-humidity index 1/ exceeds an index of 79, at which point most people begin to feel uncomfortable. In the lower desert sections, the index sometimes exceeds 86, which is considered to be extreme. However, in the southern portion of the study area such as in the communities of Nogales, Bisbee, Tombstone, and Sierra Vista, the temperature-humidity index remains in or near the comfortable range during most of the summer.

PHYSIOGRAPHY, GEOLOGY, AND MINERAL RESOURCES

Physiography

The Santa Cruz-San Pedro River Basins lie entirely within the Basin and Range physiographic province. The area is characterized by broad, semi-arid to arid valleys oriented in a north to northwest direction and separated by sharply carved mountain ranges which rise abruptly above the "plains".

The positions of alternating mountains and valleys were set mainly during Miocene and Pliocene time (Table 2.1) when the earth's crust underwent disturbances resulting in uplift, faulting, and tilting. Today's mountain ranges are generally uplifted fault blocks, and the valleys are down-faulted blocks. While erosion was wearing away the young mountains and the basins were being filled with sediment, the area continued to be subjected to varying degrees of uplift, subsidence, faulting, and tilting. As a result of intermittent volcanism, there are places where lavas are interbedded with valley alluvium.

1/ In hot weather, personal comfort increases with decreasing air temperature and relative humidity. To judge the combined effect of these two climatic elements, the U.S. Weather Bureau devised the temperature-humidity index which is defined by the following simple formula: Temperature-humidity index = 0.4 (air temperature + wet bulb temperature) + 15. Both temperatures are in degrees Fahrenheit. "Arizona Climate" edited by Christine R. Green & William D. Sellers, The University of Arizona Press, Tucson, 1964.

Table 2.1

RELATIVE GEOLOGIC TIME				* ATOMIC TIME
ERA	PERIOD		EPOCH	Millions Of Years Before the Present
CENOZOIC	QUATERNARY		HOLOCENE	
			PLEISTOCENE	2-3
	TERTIARY		PLIOCENE	12
			MIOCENE	26
			OLIGOCENE	37-38
			EOCENE	53-54
			PALEOCENE	65
MESOZOIC	CRETACEOUS		LATE EARLY	136
	JURASSIC		LATE MIDDLE EARLY	190-195
	TRIASSIC		LATE MIDDLE EARLY	225
PALEZOIC	PERMIAN		LATE EARLY	280
	CARBON-IFEROUS SYSTEMS	PENNSYLVANIAN	LATE MIDDLE EARLY	
		MISSISSIPPIAN	LATE EARLY	345
	DEVONIAN		LATE MIDDLE EARLY	395
	SILURIAN		LATE MIDDLE EARLY	430-440
	ORDOVICIAN		LATE MIDDLE EARLY	500
	CAMBRIAN		LATE MIDDLE EARLY	570
PRECAMBRIAN				3,600+

*Estimated ages of time boundaries

Poorly developed drainage systems and the existence of many lakes retarded sediment movement and accounted for rapid filling of the basins. For millions of years, the basins had no outlets; but drainage patterns became progressively more defined; and during Pleistocene time, westward drainage of the Gila River was established. Presently, all but one basin within the study area has through-drainage. In the Willcox Basin, all surface water flows inward toward the Willcox Playa. The playa is a shallow lake, covering about 51 square miles, where water gathers infrequently and evaporates quickly.

In some basins such as the San Pedro Valley, the valley fill is being dissected and removed rapidly by through-flowing streams. Aravaipa Creek, a tributary of the San Pedro River, has its headwaters in the northwestern extension of the large structural trough which contains the Willcox Basin. While no immediate threat, this stream is gradually advancing headward into the valley fill of the Willcox Basin.

The consolidated alluvial deposits filling the basins contain the principal water supplies of the study area. The most important strata are late Tertiary and early Quaternary strata, often referred to as older valley fill. They consist of interfingering sand, gravel, silt, and clay beds which have little vertical or lateral continuity. One major exception is the persistent occurrence of thick lakebed clay in the upper part of the older fill. Younger valley fill, occurring mostly as unconsolidated flood plain deposits of sand and gravel, are also important aquifers in some areas. The formations, groups of formations, or parts of a formation that contain sufficient saturated permeable material to yield significant quantities of water to wells and springs are called aquifers. Ground water occurs mostly under water table (unconfined) conditions in the aquifers of the study area; but artesian (confined) conditions occur to some extent in most, if not all, the basins. Figure 19 illustrates geologic conditions and the occurrence of ground water in a typical alluvial basin in the Santa Cruz-San Pedro River Basins.

Within the study area, the Basin and Range province is further divided into two parts - the Mexican Highland section and the Sonoran Desert section (Figure 7).

Mexican Highland Section

Approximately 70 percent of the study area lies within the Mexican Highland section in the southeast. Mountain masses, ranging from 4 to 20 miles wide and from 10 to 35 miles long occupy nearly half the section. Generally, their summits rise 2,000 to 5,000 feet above the adjoining valley floors. The highest point in the study area, at 10,713 feet above mean sea level, occurs on Mt. Graham. This peak is the summit of the Pinaleno Mountains and towers more than 7,800 feet above the Gila River Valley just outside the study area. Other prominent peaks include Chiricahua Peak on the southeastern divide at 9,695 feet above sea level; Miller Peak (9,466 feet) in the Huachuca Mountains of southeastern Cochise County; Mt. Wrightson (9,432 feet) in the Santa Rita Mountains in Santa Cruz County; and Mt. Lemmon (9,157 feet) in the Santa Catalina Mountains just northeast of Tucson.

FIGURE 7 - Physiographic Sections of the Santa Cruz-San Pedro River Basins.

Valley elevations of the Mexican Highland section range from nearly 1,800 feet above sea level along the Gila River just upstream from Florence to about 5,000 feet in the Willcox Basin. Relief between valley axes and mountain bases is mostly within the range of 500 to 1000 feet. Most of the relief occurs adjacent to the mountains on the bajada, an apron of confluent alluvial fans sloping away from the mountain front. (See Figure 19). Most valley interiors slope gently, but one noted exception is the narrow San Pedro River Valley where the valley fill has been deeply dissected. The river lies as much as 1,500 feet below the mountain bases, and most of the relief occurs within a narrow strip along the river. Steep barren slopes, headcutting gullies, severe streambank erosion, and piping soils are common.

There are five major alluvial basins and a part of another within the Mexican Highland portion of the study area. Because the rock mountain masses are relatively impermeable, the basins are mostly hydrologically separate. Table 2.2, includes a brief description of the characteristics, locations, and extent of these basins.

Sonoran Desert Section

The northwestern 30 percent of the study area lies within the Sonoran Desert section. In comparison to the Mexican Highland section, it is characterized by lower elevations; drier climate; less defined stream systems; less dissection of valley fill; gentler, more expansive valleys; and shorter, more narrow mountain ranges. The plain-like valleys occupy approximately 70 percent of the section.

Valley elevations in the Sonoran Desert section range from less than 1,000 feet above sea level at the confluence of the Santa Cruz and Gila Rivers to 3,500 feet on the bajada of the Upper Santa Cruz Basin. While the mountain ranges are relatively short and narrow and occupy a subordinate share of the Sonoran Desert, they nevertheless stand as bold, rugged landmarks jutting out of the desert. Their summit elevations range from less than 2,400 feet above sea level to 4,788 feet on Mt. Devine Peak in southern Pinal County.

There are three major alluvial basins in the Sonoran Desert portion of the study area. Brief descriptions of their locations, characteristics, and extent are included in Table 2.2.

Geology

The variety of rock types in the mountain ranges and their complex structure bear mute testimony to violent events which have taken place through geologic time. The area has been subjected to many disturbances including subsidence, sea invasions, upwarping, erosion, igneous intrusions, volcanism, faulting, and metamorphism.

Rocks ranging in age from Precambrian through Quaternary are exposed in the study area (see Geology Map).

TABLE 2.2 DESCRIPTION OF ALLUVIAL BASINS, SANTA CRUZ-SAN PEDRO RIVER BASIN

Major Alluvial Basin	Location	Size of Valley	Major Outlet	Direction of Flow	Character of Valley Fill Material	Mountains Forming Boundaries	Ground Water Resources
Mexican Highland Section							
San Bernardino Valley	Southeast corner of Arizona	15 mi. wide & 20 mi. long	Black Draw	Southward	Volcanic flows & cinders over gravel, sand, & silt.	Peloncillo Pedregosa Perilla	Very little information
Douglas Basin	South-central Cochise County	30 mi. wide & 40 mi. long	Whitewater Draw	Southward	Silt, clay, sand, & gravel. Permeability is generally low.	Chiricahua Pedegrosa Perilla Dragoon Mule	Silts and clays store large amounts of water and are the major source in the basin. Water is mostly unconfined with some localized areas under artesian pressure.
Willcox Basin	North-central Cochise & southwestern Graham Counties	12-35 mi. wide & 60 mi. long	None - Willcox Playa acts as collecting point	Inward toward Willcox Playa	Interfingering layers of sand, gravel, silt, and clay ranging from moderately consolidated to unconsolidated.	Pinaleno Dos Cabezas Chiricahua Galiuro Winchester Little Dragoon Dragoon	Lenses of unconsolidated sand and gravel yield large quantities of water. Artesian pressure results from lakebed deposits of clay and silt beneath and surrounding the Willcox Playa.
Aravaipa Valley	Southwestern Graham County	6 mi. wide & 35 mi. long. Entrenchment restricts gentle valley to 1 to 1.5 mi. in width.	Aravaipa Creek	Northwestward and westward	Young alluvium (gravel, sand, and silt) with little information known about older valley fill.	Santa Teresa Pinaleno Galiuro	Young alluvium along Aravaipa Creek is primary source of water.

TABLE 2.2 DESCRIPTION OF ALLUVIAL BASINS, SANTA CRUZ-SAN PEDRO RIVER BASIN
CONTINUED

Major Alluvial Basin	Location	Size of Valley	Major Outlet	Direction of Flow	Character of Valley Fill Material	Mountains Forming Boundaries	Ground Water Resources
Mexican Highland Section cont'd							
San Pedro Valley	Western Cochise & eastern Pinal Counties	Severely entrenched valley fill ranges from 10 to 25 mi. in width & is 120 mi. long	San Pedro River	Northwestward	Young alluvium (gravel sand, & silt) over clayey & silty gravel, silt, gravel, sandstone, & siltstone.	Galiuro Winchester Little Dragoon Dragoon Mule Tortilla Santa Catalina Rincon Whetstone Huachuca	Younger, highly permeabl valley fill along flood plain of San Pedro River is the principal source of ground water. Older valley fill contains confined water under cemented layers of silt and clay.
Sonoran Desert Section							
Upper Santa Cruz	Santa Cruz & eastern Pima Counties	Width ranges from 5 mi. in upper part to 24 mi. near Tucson. Length is 70 mi.	Santa Cruz River	Northward	Young valley alluvium (sand and gravel) over clay, sand, silt, moderately cemented gravel, & sandy gravel.	Tortolita Santa Catalina Rincon Santa Rita Patagonia Tucson Sierrita Tumacacori Atascosa	Primary source is unconfined water in older valley fill.
Lower Santa Cruz	Western Pinal County	12 to 40 mi. wide & 65 mi. long	Santa Cruz River	Northwestward	Consolidated valley fill overlain with unconsolidated, interfingering layers of sand, gravel, silt, & clay.	Black Tortilla Tortolita Sierra Estrella Palo Verde Hills Table Top Tat Momoli Sawtooth Silver Bell	Principal aquifer is unconsolidated valley fill It contains a confining middle unit of fine textured alluvium which results in artesian pressure.

TABLE 2.2 DESCRIPTION OF ALLUVIAL BASINS, SANTA CRUZ-SAN PEDRO RIVER BASIN
CONTINUED

Major Alluvial Basin	Location	Size of Valley	Major Outlet	Direction of Flow	Character of Valley Fill Material	Mountains Forming Boundaries	Groundwater Resources
Sonoran Desert Section continued							
Altar-Avra Valley	Eastern Pima County	Width ranges from 5 to 17 mi. but width where alluvium is greater than 1,000 ft. thick is only 2 to 10 mi. Length is 65 mi.	Brawley Wash	Northward	Interfingering lenses of silt, sand, and gravel.	Tucson Sierrita Cerro Colorado Los Guijas San Luis Silver Bell Rockruge Coyote Quinlan Baboquivari Pozo Verde	Older valley fill is principal aquifer. Water is unconfined above 700 feet in depth. Some confinement exists below 900 feet.

Older Precambrian rocks, including granitic and highly deformed metamorphic rocks, underlie the study area and are occasionally exposed in scattered outcrops. Some of the outcrops are extensive, as exemplified in the Tortilla, Tortolita, and the northern end of the Santa Catalina Mountains.

Small scattered outcrops of Younger Precambrian rocks, consist of quartzite, shale, limestone, diabase, and basalt. They exist in the Aravaipa Canyon area and Tortilla Mountains of eastern Pinal County, in the Vekol Mountains of southwestern Pinal County, and on the northern end of the Santa Catalina Mountains in Pima and Pinal Counties.

A sequence of sedimentary rocks was laid down as seas advanced and receded several times during the Paleozoic Era. Many of these strata have been removed by erosion or covered by valley fill; but limestone, dolomite, shale, sandstone, and quartzite remain in mountain ranges in the eastern part of the study area. In places, the sequence is more than 5,000-feet thick. Outcrops tend to be elongated and limited in extent.

Triassic and Jurassic rocks in the study area are primarily volcanic, pyroclastic, and granitic. They bear evidence of the upwarping, igneous intrusions, volcanic activity, faulting, and metamorphism which took place during the two periods. These rocks are found in mountain ranges in and around Santa Cruz County.

Several thousand feet of shale, conglomerate, and sandstone mark two advances of the sea during the Cretaceous period. Volcanic activity accompanied the latter advance. Cretaceous rocks are well represented in the mountains of the southern part of the study area.

Major mountain building activity, known as the Laramide Orogeny, marked the close of the Cretaceous and the early Tertiary periods. This activity uplifted all of Western North America. Igneous intrusive rocks and a large variety of volcanic rocks of that time occur in most mountain ranges of the study area.

Volcanic activity continued into the Tertiary and Quaternary periods while alluvium accumulated to great thicknesses in the present-day valleys. The majority of the Chiricahua and Galiuro Mountains are covered with thick accumulations of Tertiary lava flows and pyroclastic rocks. The Quaternary period is predominantly represented by valley alluvium; but it should be noted that a large mass of Quaternary basalt flows and cinder cones lies within the San Bernardino Valley in the extreme southeastern corner of the study area.

The alluvial valleys are filled with Tertiary and Quaternary gravel, sand, silt, and clay to thicknesses which exceed 5,000 feet in places. These semi-consolidated and consolidated deposits contain the principal water supplies of the study area.

Mineral Resources 1/

The Santa Cruz-San Pedro River Basins are well endowed with mineral resources. Important metallic minerals are contained in rocks of various types and ages. For example, Precambrian quartz monzonite serves as host rock for at least one important ore body; Paleozoic and Cretaceous sedimentary rocks (mostly limestone) are hosts for numerous ore bodies of copper, lead, zinc, gold, silver and manganese; Triassic, Jurassic, and Laramide intrusive bodies contain major and minor deposits of base metals; Cenozoic float and placer deposits have yielded silver ore; noteworthy non-metallic resources of marble and limestone occur within Paleozoic formations; gypsum is found in Permian limestones; sand, gravel, gypsum, and clay are contained in Cenozoic alluvium; and cinder deposits are common in a Quaternary volcanic field.

Presently, the most important mineral resources are copper, sand and gravel, silver, gold, lead, zinc, molybdenum, and gypsum. Cement, stone, and lime are also important. In 1970 the value of mineral production was $422,298,000 in Pima County, $285,166,000 in Pinal County, and $78,297,000 in Cochise County. 2/ Data for Santa Cruz and Graham Counties is withheld to avoid disclosing individual company confidential data.

Arizona has ranked first among the United States in copper production since 1910 and presently accounts for more than half the Nation's annual production. Many copper deposits have been and are being mined within the study area. The Warren (Bisbee), Old Hat (Mammoth), Pima, and Silver Bell districts are among the leading producers. Mining operations at Bisbee, however, were phased out early in 1974. Relatively new and significant production is occurring in the Casa Grande vicinity. Santa Cruz County is within an area which appears especially favorable for new discoveries of economic importance.

Early silver bonanzas, especially in the Tombstone and Pearce areas, greatly influenced Arizona history. Since 1903, however, the output of silver has come mainly as a by-product of base-metal ores. Recently, the mines at Bisbee were among the leading silver producers in Arizona. The area of Santa Cruz, western Cochise, and southeastern Pima Counties is considered to be particularly favorable for further prospecting.

Since 1940, gold also has been taken mainly as a by-product of base-metal ores. The Bisbee and Mammoth districts have been the major producers.

1/ The principal sources for the following section were: Arizona Bureau of Mines, A Resume of the Geology of Arizona, Bulletin 1971, September 1962 (4), and U. S. Geological Survey, Arizona Bureau of Mines, and U.S. Bureau of Reclamation, Mineral and Water Resources of Arizona, for use by Committee on Interior and Insular Affairs, 90th Congress, 2nd Session, 1969. Also published as Arizona Bureau of Mines Bulletin 180, May 1969 (5).

2/ Bureau of Mines.

Arizona has ranked high in the production of lead and zinc since 1940. The Warren (Bisbee), Mammoth, Harshaw, Pima, Ruby, Tombstone, and Patagonia districts are largely responsible for Arizona's high lead production. Leading zinc producing districts within the study area are Bisbee, Harshaw, Pima, Mammoth, and Cochise. Santa Cruz and western Cochise counties are included in the areas expected to produce the bulk of future lead and zinc resources.

Expanding uses and demands for molybdenum since 1914 have encouraged its mining in Arizona. Since 1933, essentially all of Arizona's molybdenum has been recovered as a by-product of treating copper ores from several districts including Mammoth, Pima, and Silver Bell.

Many small manganese deposits are scattered throughout the study area. Since 1915, its production has been significant only during times of war; and presently manganese mining in the study area has ceased.

Significant past production of tungsten from the Las Guijas, Cochise, and Huachuca districts has occurred; but the potential for future production appears slim.

The annual value of sand and gravel ranks second to copper. Deposits occur in recoverable concentrations in Cenozoic sediments mainly in alluvial fans, buried stream channels, and terraces near mountain fronts. The best and most accessible deposits are being exploited in the Tucson area. Also, significant production is occurring in the Florence, Bisbee, Willcox, Casa Grande, and Nogales areas.

Deposits of gypsum occur in the Empire, Whetstone, Sierrita, and Santa Rita Mountains; but the major share of Arizona's production comes from Cenozoic valley fill in the San Pedro Valley in eastern Pinal County.

Many other mineral resources occur within the study area. Those which have been or are being produced on a small scale or which have apparent potential for future production include iron, vanadium, antimony, beryllium, tellurium, selenium, uranium, rare earths, zircon, barite, various rock types for crushed, broken and dimension stone, diatomaceous earth, bentonite, refractory clay, structural clay, feldspar, fluorspar, gem stones, marble, limestone, dolomite, mica, quartzite, brines, shale, sulphur, and zeolites. Improved methods of prospecting, mining, metallurgy, and transportation and new uses for various minerals will undoubtedly result in initiating or increasing the production of many mineral resources in the future.

There is the possible existence of economically significant geothermal resources at great depth in the study area. Presently, there are only surface indications in the form of thermal springs and wells. These do not necessarily indicate great geothermal resources. Test drilling has occurred north of the study area near Chandler, but very little data are available at this time.

Introduction

The appraisal of the water resources involves the analysis of the availability of water in all its forms - vapor, liquid, and solid. The process by which water is evaporated to accumulate as clouds in the atmosphere, returned as precipitation, and enters the streams and ground water reservoirs is called the hydrologic cycle (Figure 8). The hydrologic cycle is continuous and is one of the most important processes that occurs in nature. Without water, man could not exist.

Water in some form occurs throughout the study area, but the amount and quality varies greatly. The availability of water in any locality is dependent not only upon the climate, but the terrain and geology of the area. Precipitation, the source of all water, is related to the climate. The amount of available surface or ground water is related to precipitation, and its occurrence is determined primarily by the terrain and geology of the area.

Because of the arid climate, most of the precipitation that falls in the Santa Cruz-San Pedro study area is lost by evaporation. However, a limited amount of surface runoff does occur, and a portion infiltrates into the ground and becomes a part of the ground water system.

Because of the diverse physical characteristics that control the occurrence and movement of water on the surface and underground, an appraisal of the surface water resources of an area differs from an appraisal of its ground water resources. For this reason, they are discussed separately in the following sections.

Surface Water

Surface water is a function of both streamflow and surface storage. Streamflow is that part of precipitation that appears in streams. Surface storage is water that is impounded on the surface in manmade reservoirs or water that is naturally detained in a drainage basin.

Surface water storage is limited within the Santa Cruz-San Pedro River Basins and is negligible within the Willcox Playa-Whitewater Draw area. The amount of conservation storage capacity available within the study area is less than 60,000 acre-feet. This figure includes an estimated 15,000 acre-feet of water in approximately 3,200 stock watering tanks and charcos scattered throughout the study area. An additional 43,500 acre-feet of storage is available in some 30 fish and wildlife, recreation, and other multiple use impoundments. The remainder of the surface water storage in the study area is found in large mine tailing reservoirs constructed in connection with mining operations.

Streamflow in the Santa Cruz-San Pedro Basins is typical of that in other arid or semi-arid lands where channels are dry for long periods of time. The flows are confined generally to the channels, although they frequently inundate the flood plains where the channels are not deeply

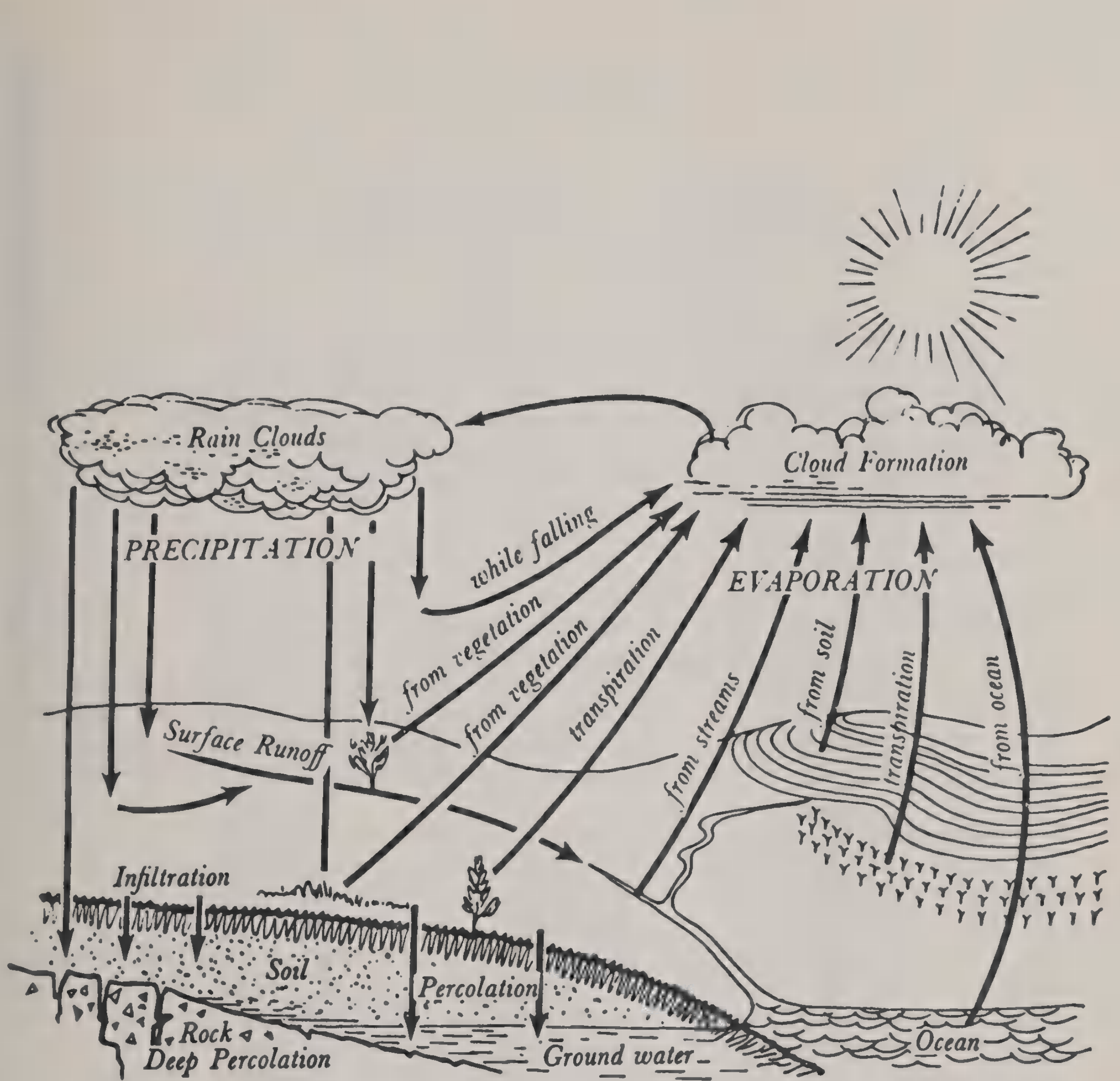


FIGURE 8 - The Hydrologic Cycle - a descriptive presentation.
Source: Ackerman, W.C., E.A. Coleman, and H.A. Ogrosky.
From Ocean to Sky to Land to Ocean in the Yearbook of
Agriculture 1955, U.S. Department of Agriculture, pp. 41-51. (6)

incised. Most of the streamflow in the basin is in response to direct runoff from rainfall. Ground water sustains flow in only a few places.

Streamflow in all portions of the basin is extremely variable, and the arithmetic average of annual flows has little meaning with regard to the amount of flow that may be expected each year. Because of this extreme variability, long-term gaging station records are important for water resource planning, management, and development.

A few gaging stations have been in operation in the study area for more than 50 years. Streamflow data for the period of record for the San Pedro River at Charleston are shown in Figure 9. Similar data for the Santa Cruz River at Tucson and Sabino Creek near Tucson are shown in Figures 10 and 11. These graphs illustrate the extreme variability of the streamflow in the study area and indicate that planning based on short periods of record can be seriously in error.

Seasonal distribution of the recorded streamflows can be noted from the hydrographs of Figures 12, 13, and 14. These hydrographs show the minimum, the median, and the maximum monthly flows for each calendar month for the same three gaging stations used to illustrate the yearly discharge variability. In the Santa Cruz Basin, the range in flow for most months is more than four orders of magnitude. The lowest median flow generally occurs in June, although on the Santa Cruz River near Tucson, the median is equal to zero for nine months out of the year.

Figure 15 shows the distribution of average annual unit runoff in the study area. The total flow from a drainage basin, as measured at a gaging station, is expressed on the map in terms of average depth of yearly runoff in inches over the basin. The maps graphically illustrate that runoff is greatest in the mountains and lowest in the valley regions. This results from higher precipitation over the mountains and the relative impermeability of the mountain soils. Where stream channels leave the mountains and enter alluvial basins, the unit runoff of a stream tends to decrease in a downstream direction. This is due to permeable channels, high evaporation rates, and low unit runoff at the lower elevations.

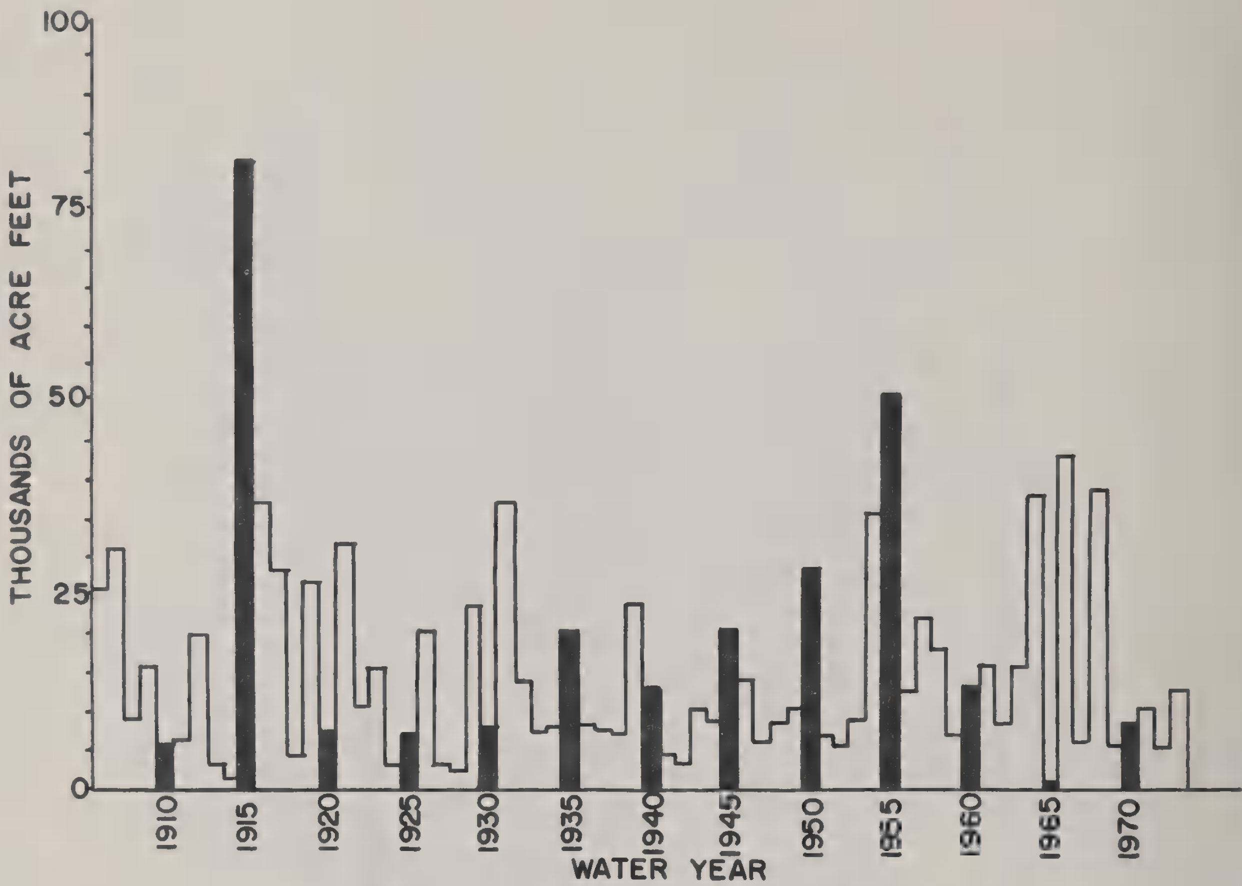
Due to the permeable nature of some of the stream channels, large volumes of flood water are lost to infiltration as a flood progresses downstream. The flood of September 12-15, 1965 on the Santa Cruz River illustrates the natural channel losses that can occur within the study area. The flood volume diminished from 682 acre-feet at Lochiel to 1.59 acre-feet at Tucson. The average annual infiltration along this reach ranges from 320 to 680 acre-feet per mile (7). Similar channel losses can occur in other parts of the study area with the infiltration ranging from near zero to over 800 acre-feet per mile.

Description of Basins

With respect to streamflow, the study area has been divided into six distinct hydrologic basins (Figure 16). These are the Gila River subarea, the Santa Cruz River Basin, the San Pedro River Basin, the Willcox Basin, the Douglas Basin, and the San Bernardino Valley.

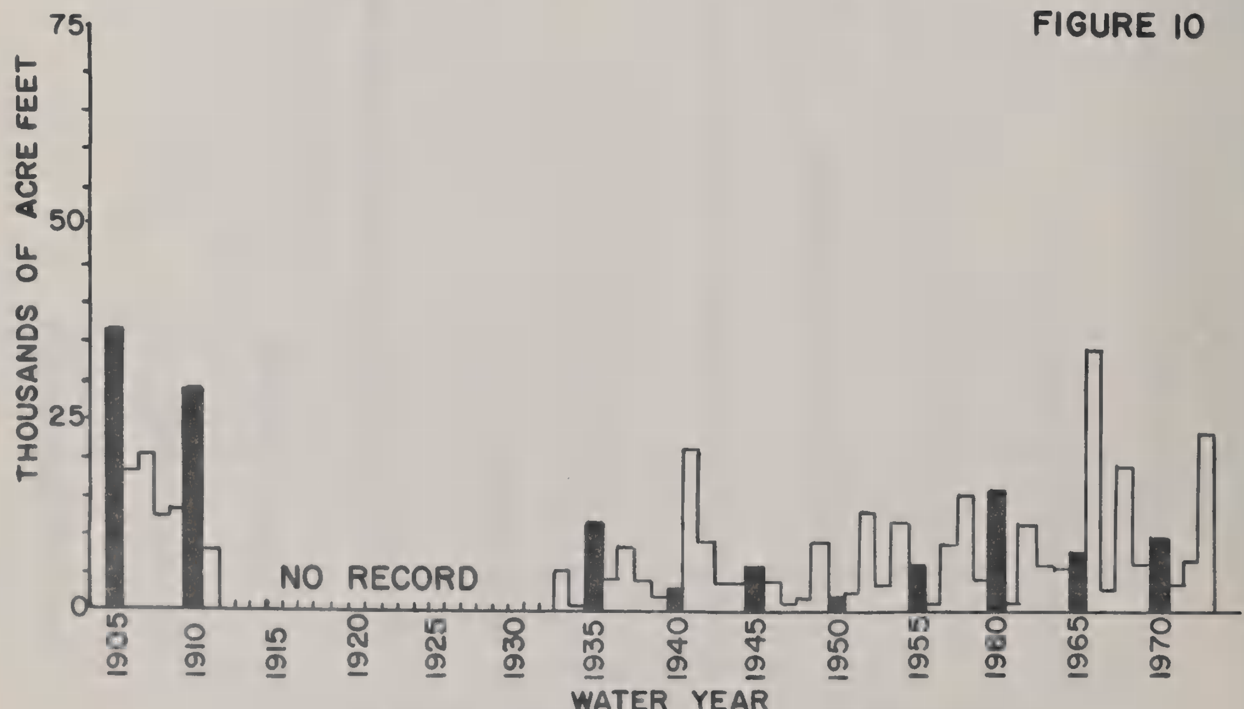
SAN PEDRO RIVER AT CHARLESTON, ARIZ.

FIGURE 9



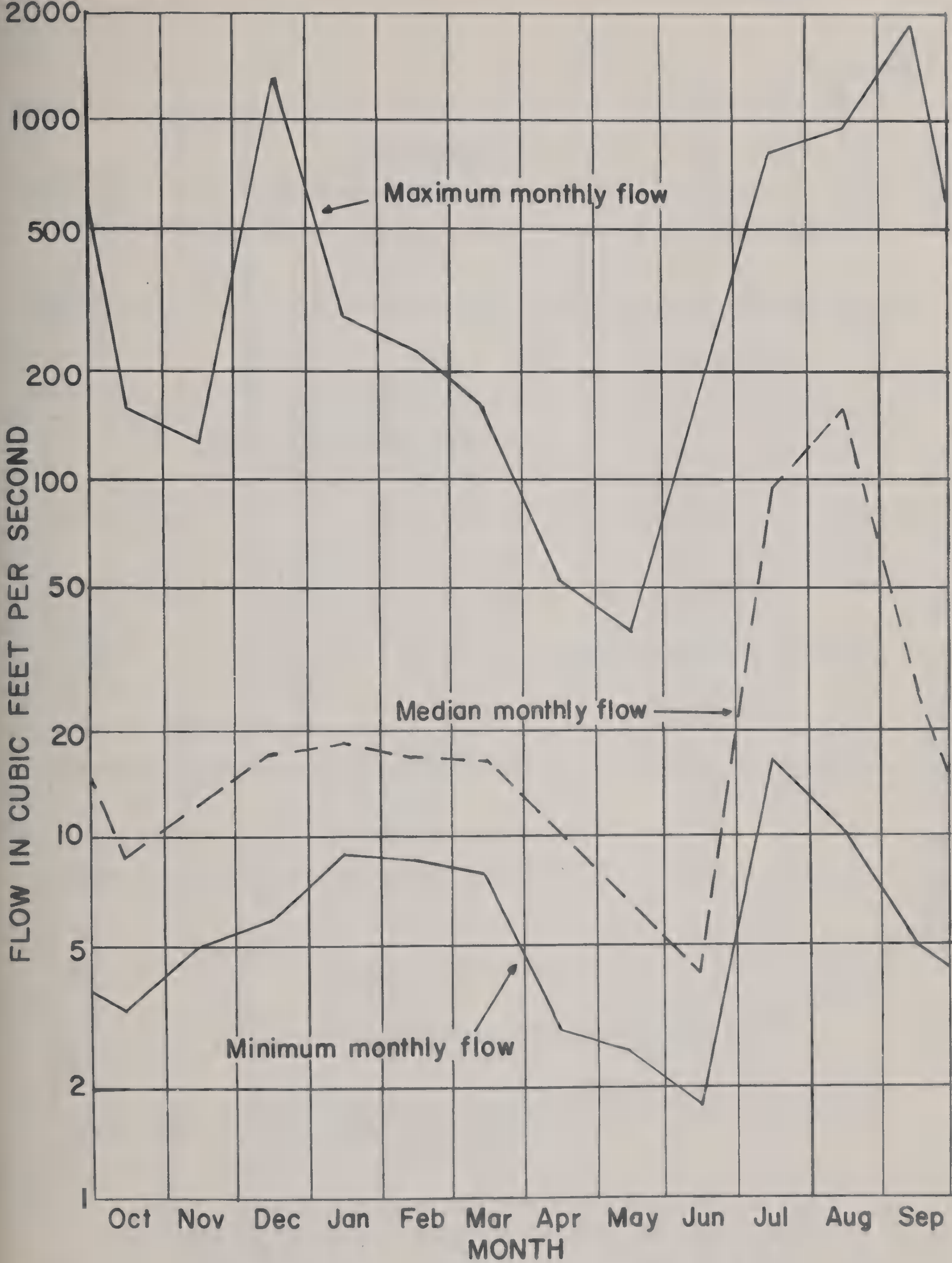
SANTA CRUZ RIVER AT TUCSON, ARIZ.

FIGURE 10



SABINO CREEK NEAR TUCSON, ARIZ.

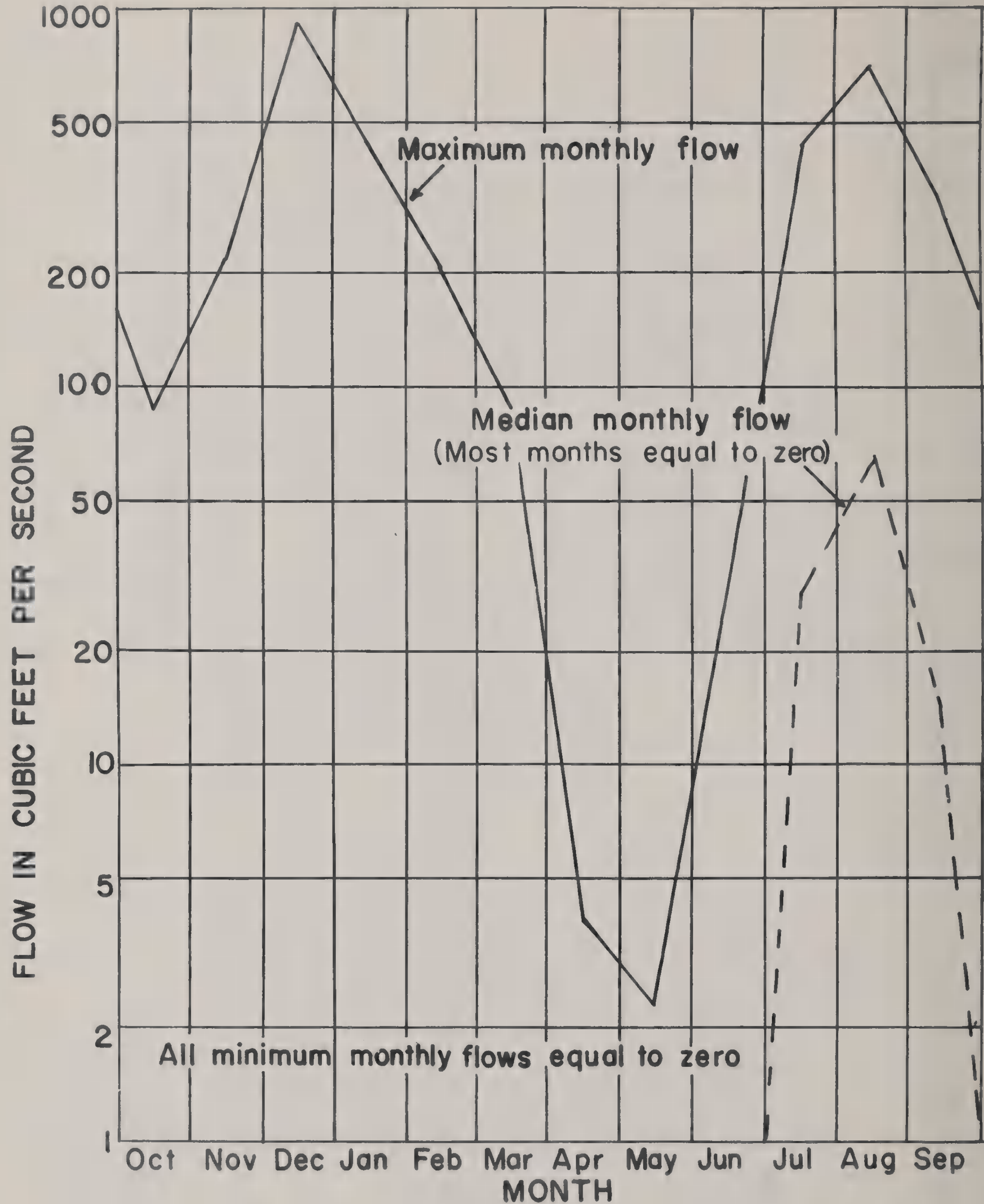
FIGURE 11



Maximum, minimum and median monthly flows, San Pedro River near Charleston for period 1904-5, 1912-73

FIGURE 12

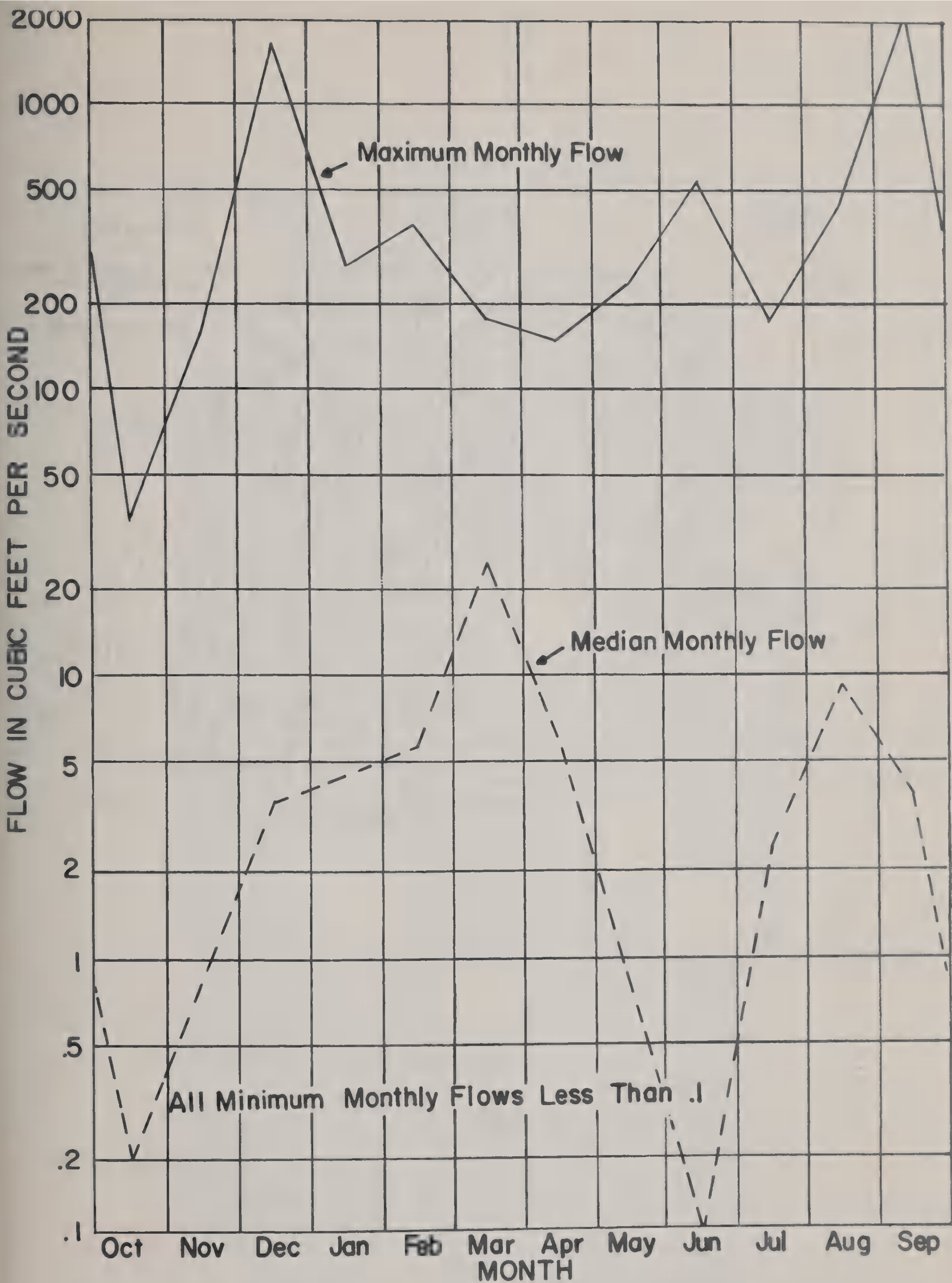
Source: U.S. Geological Survey



Maximum, minimum and median monthly flows, Santa Cruz River at Tucson for period 1906-1973

Source: U.S. Geological Survey

FIGURE 13



Maximum, minimum and median monthly flows, Sabino Creek near Tucson for period 1904-11, 1932-73

FIGURE 14

Source: U.S. Geological Survey

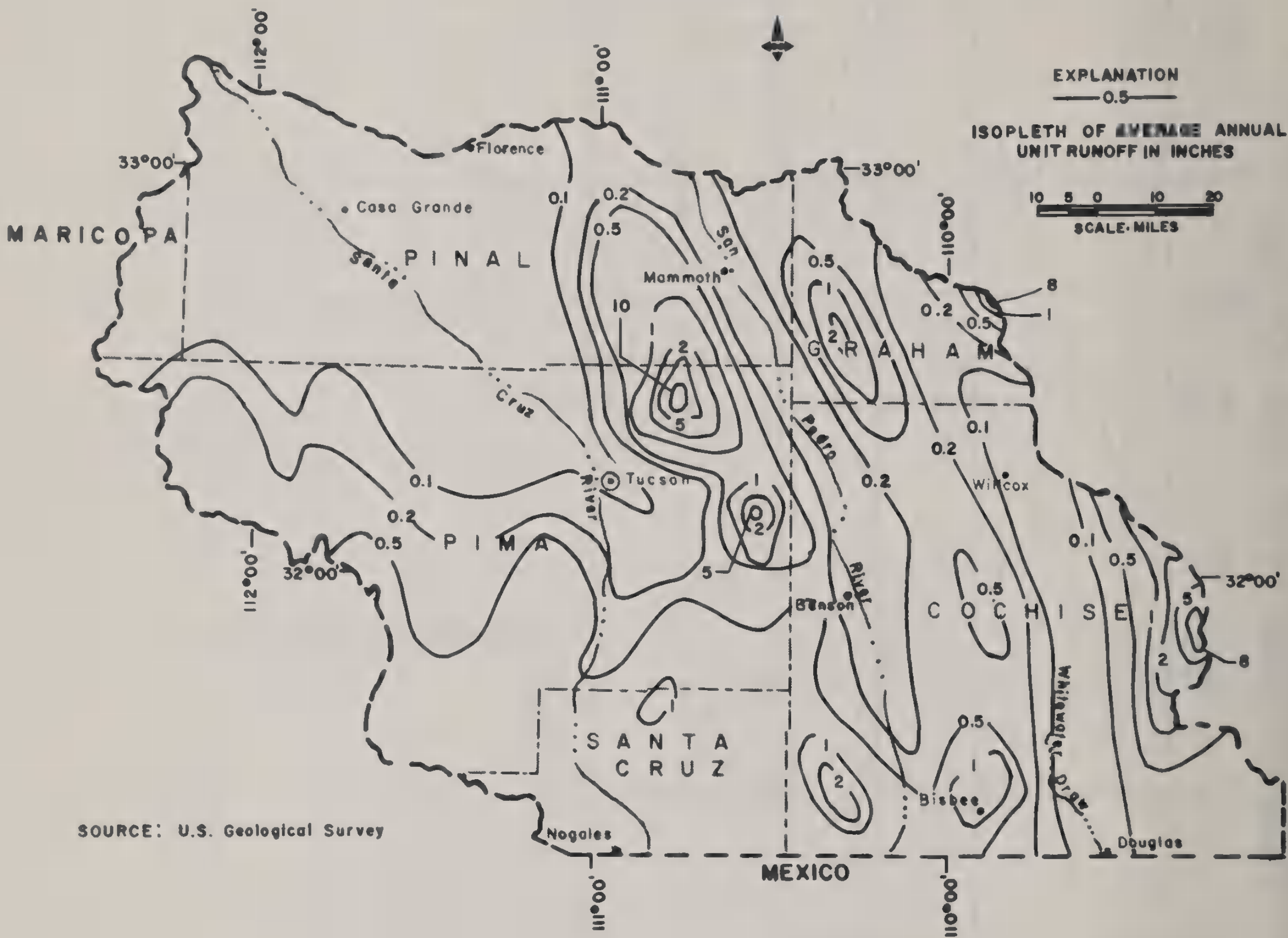


FIGURE 15 - Average Annual Unit Runoff in the Santa Cruz-San Pedro River Basins.

FIGURE 16 - Surface Water Study Areas and Locations of Gaging Stations in the Santa Cruz-San Pedro River Basins.

EXPLANATION

▲ 4800
Gaging Station
(See Tables 2-3, 2-4, and 2-5)

∼ Drainage Divide

1. Gila River Subarea
2. Santa Cruz River Basin
3. San Pedro River Basin
4. Willcox Basin
5. Douglas Basin
6. San Bernardino Valley Area

Discussions relative to each of these areas follow and include tables listing streamflow data for all gaging stations that have been in operation for five years or more. Locations of these gages are shown in Figure 16.

In most instances, the data listed for each station are drainage area, period of record, average runoff, maximum and minimum runoffs, and unit runoff in inches. The unit runoff figures provide a useful measure of the flow characteristics of an area. These values, as most of the values in the tables, are influenced by different periods and lengths of record, surface water diversions and storage, and ground water pumpage in the area above the gaging stations. Thus, use of the tabular values to compare flow characteristics for different areas should include an evaluation of the more extensive data available in publications of the U.S. Geological Survey and other sources.

Gila River Subarea. The area encompasses about 1,500 square miles. The northern boundary is the reach of the Gila River from Winkelman to Laveen (Figure 16).

There are no streamflow records for the subarea. The unit runoff within the subarea, however, is estimated to range from 0.1 inch in the Florence-Casa Grande area to about 0.5 inches in the Tortilla Mountains (Figure 15). The major portion of surface water used in the subarea originates outside the subarea and is diverted from the Gila River by the Ashurst-Hayden Dam. The water is diverted into the Florence-Casa Grande Canal and is either delivered directly to the farmers or is stored in the Picacho Reservoir. The long-term average annual diversion (1929-1972) is approximately 193,000 acre-feet. 1/

Santa Cruz River. The basin includes about 8,210 square miles in Arizona and about 395 square miles in Mexico. The river heads in the San Rafael Valley in Arizona, flows southward into Mexico, turns west and then north and re-enters Arizona near Nogales. From this point, it flows northward through Tucson, and then northwestward to its confluence with the Gila River (Figure 16). The Santa Cruz River has four major tributaries which nearly parallel the upper reaches of the river. These are Pantano Wash, Brawley Wash, Santa Rosa Wash, and Vekol Valley.

The unit runoff in the basin is small; it is less than 0.1 inches in the northern part and ranges from 0.1 to 0.5 inches in most of the rest of the area (Figure 15). At higher altitudes in the Santa Catalina and Rincon Mountains, unit runoff is estimated to be as much as 10 inches per year.

Flow in the Santa Cruz River is measured at six gaging stations on the main stem (Figure 16). Thirteen additional gages are located on tributaries to the river; most of these are in the Tucson area. Sonoita Creek near Patagonia and Santa Rosa Wash near Sells are the only tributaries to the Santa Cruz River outside the Tucson area which have had gaging stations in operation for more than five years. Data for these stations are given in Table 2.3.

1/ Streamflow records, U.S. Geological Survey.

TABLE 2.3

SUMMARY OF STREAMFLOW DATA AT SELECTED GAGING STATIONS IN THE SANTA CRUZ RIVER AREA, ARIZONA
(Station numbers are those used in publication of surface-water reports, except prefix 9 is omitted. Figure 16 gives locations of gaging stations.)

				Streamflow				
		Drainage area	Period of record	Average		Maxi-mum	Mini-mum	Unit Runoff
Sta. No.	Gaging Sta.	(sq. mile)	(water yrs)	(cfs)	(ac.ft.)	(cfs)	(cfs)	(inch)
4800....	Santa Cruz River near Lochiel	82.2	1949-70	3.29	2,380	4,810	0	0.54
4805....	Santa Cruz River Nogales	533.0	1912-22 1929-70	23.4	16,950	15,200	0	0.60
4815....	Sonoita Creek near Patagonia	209.0	1930-33 1935-70	8.21	5,950	14,000	0	0.53
4820....	Santa Cruz River at Continental	1,662.0	1940-46 1951-70	19.6	14,200	18,000	0	0.16
4824....	Airport Wash at Tucson	22.0	1965-70	.41	294	823	0	0.24
4825....	Santa Cruz River at Tucson	2,222.0	1905-70	22.1	16,010	16,600	0	0.14
4830....	Tucson Arroyo at Vine Ave.,Tucson	23.4 8.2	1944-52 1956-70	.68 .87	492 630	 5,000	0 0	0.39 1.44
4831....	Tanque Verde Creek near Tucson	43.0	1959-70	8.87	6,430	3,080	0	2.81
4833....	Sabino Creek near Mount Lemmon	3.19	1951-58	1.63	1,180	344	0	6.94
4840....	Sabino Creek near Tucson	35.5	1904-11 1932-70	12.3	8,910	7,730	0	4.70
4842....	Bear Creek near Tucson	16.3	1959-70	5.04	3,650	1,150	0	4.20
4845....	Rillito Creek near Wrightstown	221.0	1940-45	17.3	12,520	9,000	0	1.07
4846....	Pantano Wash near Vail	457.0	1959-70	7.34	5,320	9,960	—	0.23
4850....	Rincon Creek near Tucson	44.8	1952-70	4.94	3,580	8,250	0	1.50
4858.5..	Rillito Creek near Tucson	892.0	1908-70	16.4	11,880	24,000	0	0.24
4863....	Camada Del Oro near Tucson	250.0	1965-70	2.53	1,830	13,900	0	0.14
4865....	Santa Cruz River at Cortaro	3,503.0	1939-46 1950-70	31.4	22,770	17,000	0	0.12
4885....	Santa Rosa Wash near Vaiva Vo, near Sells	1,782.0	1954-70	15.7	11,370	53,100	0	0.12
4890....	Santa Cruz River near Laveen	8,581.0	1940-46 1948-70	20.3	14,710	9,200	0	0.03

Prior to extensive ground water pumping in the Santa Cruz River Basin, the surface water runoff was greater than in recent years. Prior to pumping, ground water was discharged locally as streamflow and spring flow (8). The system has been altered (9) (10) so that most of the streamflow is now lost to infiltration and recharges the ground water reservoir. The streams in the basin today are dry most of the time, and the median number of days per year of no flow past the several gaging stations is about 320 to 330 days. The median number of days per year of no flow in Rillito Creek is about 335. Streams that are nearer to the mountains than the Santa Cruz River also are dry for long periods. Rincon Creek can be expected to be dry 250 days per year, and Sabino Creek about 50 days. Pantano Wash, at the gaging station near Vail, generally has flow because ground water is forced to the surface by a bedrock barrier. A short distance downstream from the gage, the flow infiltrates into the streambed; and the periods of no flow in the ungaged part of Pantano Wash probably closely match those of the Santa Cruz River and Rillito Creek.

Because of the variability in streamflow and the lack of storage reservoirs in the Santa Cruz Basin, the infiltration of streamflow into the ground water reservoir is critical to the water resources in the area. It has been estimated that almost 75 percent of the surface water that flows into the main stream channels upstream from Rillito is infiltrated into the ground, and most of this water (about 90 percent) becomes a part of the ground water system (10). The same conditions probably exist in the major portion of the remaining parts of the Santa Cruz Basin.

The only surface water resource in the basin that has not been tapped to any great extent is that of major floodflows. These generally occur during the months of July, August, and September. Flood peaks are more evenly distributed throughout the year on streams having drainage areas that extend high into the mountains, such as Sabino Creek. In the Sabino Creek drainage, previously precipitated snow commonly is supplemented by rain; and winter floods occur with more regularity than at lower altitudes that have no snow cover. Through the construction of storage reservoirs, these floodwaters could be stored and used to supplement ground water pumpage. Due to their variability, the floodwaters generally are not adequate as a single source for water supply.

San Pedro River. The river heads in Sonora, Mexico, crosses into Arizona near Palominas, and flows northward to its confluence with the Gila River near Winkelman, Arizona (Figure 16). The drainage area is about 4,490 square miles, of which about 690 square miles are in Mexico. The basin is long and narrow and is enclosed by many northward-trending mountain ranges. The basin is characterized by many small tributaries. Except for Aravaipa Creek and Babocomari River, the tributary drainage areas are small.

The unit runoff ranges from 0.2 to 0.5 inches in most of the area (Figure 15). Long-term discharge records are available for four gaging stations on the San Pedro River - at Palominas, at Charleston, near Redington, and for a station near Mammoth which is no longer in operation (Table 2.4). A new gaging station was installed near the mouth of the San Pedro River in January 1966 to replace a former station located a

TABLE 2.4

SUMMARY OF STREAMFLOW DATA AT SELECTED GAGING STATIONS IN THE SAN PEDRO RIVER AREA, ARIZONA

(Station numbers are those used in publication of surface-water records, except prefix 9 is omitted. Figure 16 gives locations of gaging stations.)

				Streamflow				
		Drainage area	Period of record	Average		Maximum	Minimum	Unit Runoff
Sta. No.	Gaging Station	(sq. mile)	(water yrs)	(cfs)	(ac.ft.)	(cfs)	(cfs)	(inch)
4705....	San Pedro River at Palominas	741.0	1/	31.6	22,890	22,000	0	0.58
4708....	Garden Canyon near Fort Huachuca	8.38	1959-64	1.57	1,140	81	0	2.55
4710....	San Pedro River at Charleston	1,219.0	1904-05 1912-70	61.4	44,480	98,000	.5	0.69
4720....	San Pedro River near Redington	2,939.0	1943-46 1950-70	46.4	33,620	28,600	0	0.21
4725....	San Pedro River near Mammoth	3,610.0	1931-40	61.6	44,600	50,000	0	0.23
4730....	Aravaipa Creek near Feldman	541.0	1931-42 1966-70	30.0	21,740	10,500	.3	0.75
4735....	San Pedro River 2/ at Winkelman	4,471.0	1966-70	46.0	33,330	15,000	0	0.14

1/ Period of record: 1930-33, 1935-40, 1950-70

2/ This station replaced station 4734 (near Winkelman); period of record April 1962 through December 1965; drainage area 4449 square miles.

short distance upstream. The unit runoff for the six-year period of record at the present location is 0.14 inches (Table 2.4). Only two streamflow gaging stations are located on tributaries to the San Pedro River. These are on Aravaipa Creek near Feldman and Garden Canyon near Fort Huachuca. Data for these two gages are given in Table 2.4.

Flow in the San Pedro River is continuous where the streambed intercepts the water table or where it is fed by springs. Elsewhere, it flows only in direct response to precipitation. Long-term records of low flows (lowest mean discharges for 90 consecutive days) for the San Pedro River at Palominas, at Charleston, and near Redington, show the variation in the magnitude and duration of the flow (Figure 17). The percentage of time that the daily flows equal or exceed one cfs (cubic feet per second) at selected gaging stations in the San Pedro River Valley is given below:

Station	Period Of Record	Percentage of Time That Daily Flow Equals or Exceeds One cfs
San Pedro River at......... Palominas	1930-33 1935-40 1950-67	69
San Pedro River at......... Charleston	1928-33 1935-67	99+
San Pedro River near....... Redington	1943-46 1950-67	44
San Pedro River near....... Mammoth	1931-40	44
Aravaipa Creek near........ Mammoth	1919-21 1931-40 1941-42 1966-67	88

Source: Arizona Water Commission, Bulletin No. 4 (11)

During most summers, there are periods of no flow at the Palominas gaging station. At Charleston, the underlying bedrock forces subsurface flow to the surface and river flow is continuous. From 1928 to 1970, the minimum daily flow at this station was 0.5 cfs (11). From Charleston downstream to the Narrows, a point about 11 miles north of Benson, the river flow is intermittent. At the Narrows, flows occur only in direct response to precipitation. In an area several miles north of Cascabel, subsurface flow is again forced to the surface; and the flow is probably perennial in the reach that extends almost to the gaging station near Redington. Flow usually ceases during the spring or early summer at the gaging station near Redington. In the reach downstream from Redington, the stream channel is usually dry except where seeps and springs contribute flow to the river. Leroy Springs, located about six miles south of Winkelman, contributes flow to the river when spring flow is not diverted for irrigation. Based on 12 discharge measurements made since

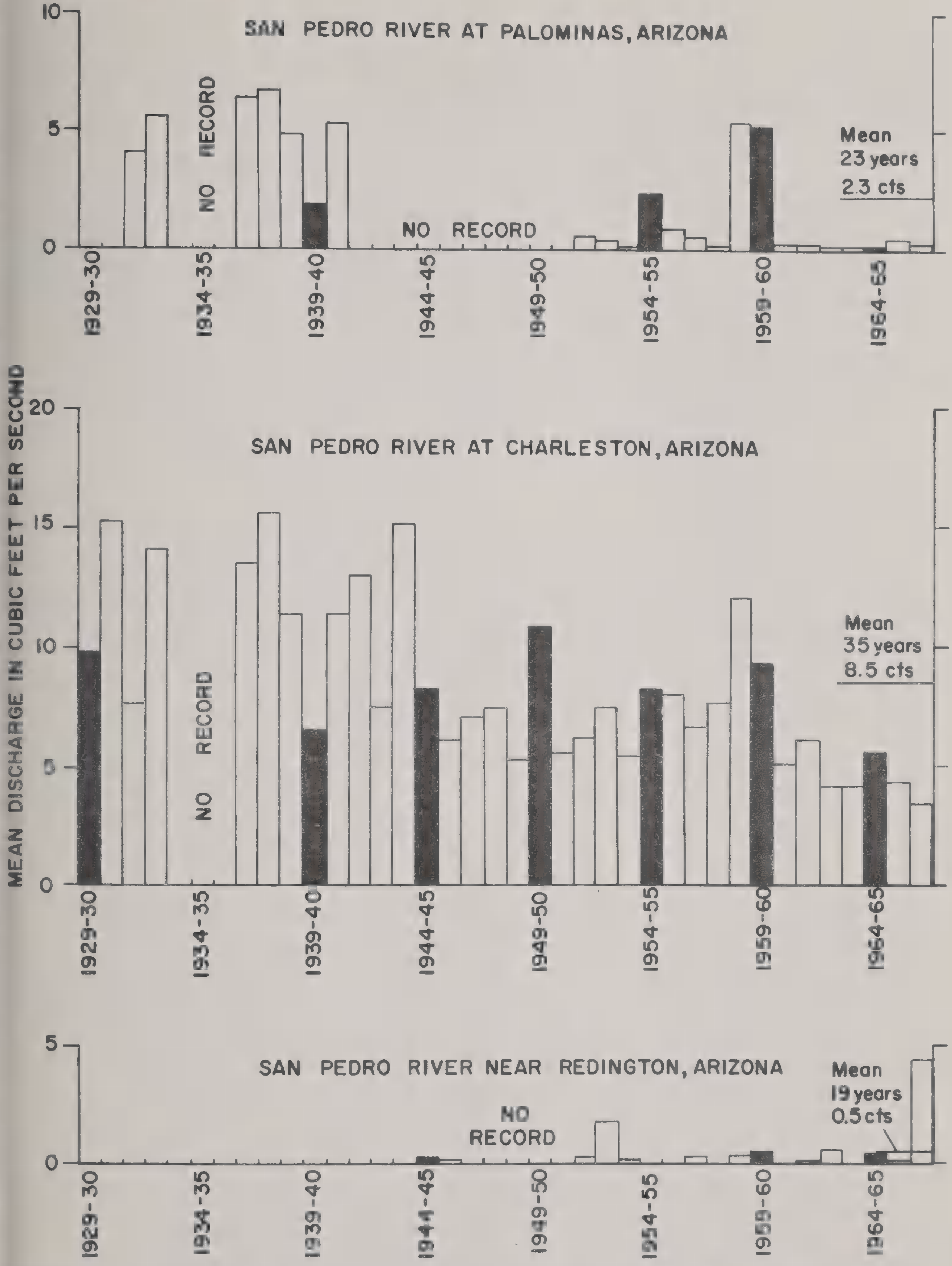


FIGURE 17 - Lowest Mean Discharges for 90 consecutive days in the 12-month period, April 1 through March 31, for the San Pedro River at Palominas, at Charleston, and near Redington. (Source: Arizona Water Commission Bulletin 4).

June 1962, the U.S. Geological Survey has estimated the flow from the springs to range between 1.1 and 3.5 cfs, with an average flow of 2.3 cfs. Flow at the mouth of the San Pedro River ceases during extended periods of no precipitation.

The base flows of spring-fed tributaries, such as the Babocomari River and Aravaipa Creek, are lost to evapotranspiration and infiltration. The Babocomari River, a major tributary in the upper part of the basin, has perennial flow only in parts of its lower reaches. Aravaipa Creek, located in the lower part of the basin, has perennial flow at the gage but is usually dry six miles downstream where it joins the San Pedro River.

Willcox Basin. The basin is closed, draining an area of about 1760 square miles. The Willcox Basin is separated from the Whitewater Draw area to the south by low-lying hills. Surface waters originate in the Pinaleno and Chiricahua Mountains to the north and east and in the Dragoon and Little Dragoon Mountains to the west. Runoff from the mountain areas drains toward the Willcox Playa, located in the central part of the basin.

Little is known about the surface-water flow to the Willcox Playa. A gaging station was operated on West Turkey Creek for six years. The unit runoff for the period of record for a 19 square mile watershed was 5.47 inches (Table 2.5); however, this runoff was from the high altitudes in the Chiricahua Mountains and is not indicative of the amount of runoff reaching the playa. The unit runoff is estimated to range from 0.1 inches on the valley floor to as much as 8 inches at the top of the Chiricahua Mountains (Figure 15).

Most of the runoff which originates in the mountains, either is lost to deep percolation along the mountain fronts or is transpired by phreatophytes growing along the stream channels. The surface waters which do reach the playa are spread out over a large area and are evaporated or are transpired by vegetation growing around the perimeter of the playa. Little, if any, is available for use by man.

Douglas Basin. As described in this report, the basin extends from the international boundary northward to a group of low hills that form the surface drainage divide between it and the Willcox Basin. It is bounded on the west by the Dragoon and Mule Mountains and on the east by the Chiricahua, Pedregosa, and Perilla Mountains (Figure 16). The basin is drained by Whitewater Draw, which heads in Rucker Canyon in the Chiricahua Mountains and flows westward around the north end of the Swisshelm Mountains, and then southward into Mexico. The basin averages about 30 miles in width, is about 40 miles long, and has an area of about 1,023 square miles above the gaging station on Whitewater Draw near Douglas.

Most of the tributaries of Whitewater Draw are intermittent streams, and add only small amounts of water to the main drainage. Whitewater Draw is intermittent except for a short reach at its headwaters in Rucker Canyon and from a point near Douglas southward into Mexico. The flows in these two reaches are sustained by ground water discharge. In extremely dry years, however, there may be no flow for long periods even in these reaches.

TABLE 2.5

SUMMARY OF STREAMFLOW DATA AT SELECTED GAGING STATIONS IN THE WILLCOX AND DOUGLAS BASINS, ARIZONA

(Station numbers are those used in publication of surface-water records, except prefix 9 is omitted. Figure 16 gives location of gaging stations.)

Station No.	Gaging Station	Drainage area (sq. mile)	Period of record (water yrs.)	Average cfs	Average ac.ft.	Maximum (cfs)	Minimum (cfs)	Unit runoff (inch)
5365.......	West Turkey Creek near Light	19	1919-25	7.65	5,540	(1)	0	5.47
5370.......	Whitewater Draw near Rucker	40	1919-25	7.61	5,510	(2)	0	2.59
5375.......	Whitewater Draw near Douglas	1,023	(3)	10.50	7,610	5,060	0	0.14

(1) Maximum discharge not determined; probably occurred July 31, 1921.

(2) Maximum discharge not determined; probably occurred Nov. 23, 1919.

(3) Period of record: 1915-19, 1930-33, 1935-46, 1947-1970.

The unit runoff over the basin ranges from 0.1 inches on the valley floor to nearly 8 inches in the Chiricahua Mountains (Figure 15). The unit runoff as measured at the gaging station near Douglas is 0.14 inches (Table 2.5). Although the base flow in this reach is sustained by ground water, the major part of the streamflow passing the gage is floodwater runoff. Less than four percent is attributed to ground water discharge. In the last several years, the amount of ground water discharge has been on a gradual decline. This is attributed to the progressive lowering of the water table in the basin upstream from the gage.

San Bernardino Valley. Lying in the extreme southeastern corner of the study area, the valley comprises about 400 square miles (Figure 16). It is drained by Black Draw which flows into Mexico. Data with reference to streamflow is limited. Stream gages have not been operated in the area. Average annual runoff is estimated to vary between 0.1 inches in the valley to over 2.0 inches in the mountain regions. Streamflow in Guadalupe Canyon is perennial. Other stream channels in the area are generally dry for long periods.

Live Streams

The vast majority of streams in the study area can be classified as either ephemeral streams or intermittent streams. As used in this report, the term ephemeral applies to stream reaches which flow only in direct response to precipitation and receive little or no water from springs and no continued supply from melting snow. The term intermittent applies to stream reaches which flow during wet weather or during a part of the year. Streams which have flow throughout the year under average conditions have been classified as live streams. These streams were not classified as perennial streams because during periods of unusually low rainfall, flow ceases in some reaches. For instance, the San Pedro River is shown as live from St. David to the Mexico border on Figure 18 and in Table 2.6. During periods of drought, some sections of this reach may be dry; although ground water in the channel bed may be very near the surface. Another example of this is Madera Canyon, which has not had flow during periods in 1973 and 1974. This situation is more typical of the lower reaches of streams than the upstream reaches at the higher elevations.

The type of vegetation bordering the streams is displayed in Table 2.6. The vegetation contributes to the aesthetic and environmental value of the stream. Average widths of riparian vegetation stands are included in the table since this type of vegetation is in narrow bands along the streams. Environmentally, this resource is extremely valuable because of its scarcity. Widths of other types of vegetation are not included because these consist of large, contiguous areas with poorly defined borders. Although vegetation may be denser or of a different species along these sections of streams, these areas were too small to display. Live streams are not monitored for water quality. Consequently, little or no data are available on this aspect of live streams. However, the quality is adequate for fish habitat and swimming in those sections having sufficient quantity. The water is suitable for wildlife or livestock drinking. In those streams which are spring-fed, the water is generally suitable for human consumption in the upper reaches near the springs.

TABLE 2.6

LIVE STREAMS IN THE SANTA CRUZ-SAN PEDRO RIVER BASINS

Stream or River	County	Live Stream Length (Miles)	Average Width of Channel (Feet)	Type of Bordering Vegetation and Lengths 1/	Width of Riparian (Feet)
Rucker Canyon	Cochise	5.5	5	P-MC-2 (3.5 mi.), OW-C-2 (2 mi.)	
Turkey Creek	Cochise	8.3	5	R (2.5 mi.), P-MC-2 (4.3 mi.), OW-C-2 (1.5 mi.)	500
Pine Creek	Cochise	6.0	5	OW-C-1 (1 mi.), OW-C-2 (2 mi.), P-MC-2 (3 mi.)	
San Pedro River	Cochise	6.0	100	R (6 mi.)	600
	Cochise	45.0	100	R (22 mi.), D-1 (17 mi.), G(6 mi.)	800
Babocomari River	Cochise	10.0	20	R (4 mi.), D-1 (6.0 mi.)	600
Leslie Canyon	Cochise	0.5	5	G (0.5 mi.)	
Aravaipa Creek	Graham	6.0	4	R (6 mi.)	400
Grant Creek	Graham	5.0	6	P-MC-2 (2.0 Mi.), OW-C-2 (3 mi.)	
Post Creek	Graham	3.0	6	P-MC-3 (2 mi.), P-MC-2 (1 mi.)	
San Pedro River (Leroy Springs)	Pinal	1.0	100	Being Planned for Development	
Aravaipa Creek	Pinal	14.8	4	R (14.8 mi.)	400
Canada Del Oro	Pinal	7.0	6	OW-C-1 (4 mi.), G (3 mi.)	
Canada Del Oro	Pima	6.0	6	P-MC-3 (2 mi.), OW-C-2 (4 mi.)	
Sabina Canyon	Pima	12.5	6	D-2 (4.5 mi.), OW-C-2 (3 mi.), P-MC-1 (2 mi.), P-MC-2 (3 mi.)	
East Fork	Pima	4.0	6	OW-C-2 (1 mi.), OW-C-1 (1 mi.), P-MC-1 (2 mi.)	
Lemmon Canyon	Pima	2.3	6	P-MC-1 (2.3 mi.)	
San Pedro River	Pima	2.0	100	R (2 mi.)	1000
Arivaca Creek	Pima	5.0	5	R (3 mi.), C (2 mi.), Being Developed for Urban (3 mi.)	300

Page 1 of 2 pages.

TABLE 2.6 (Continued)

LIVE STREAMS IN THE SANTA CRUZ-SAN PEDRO RIVER BASINS

Stream or River	County	Live Streams Length (Miles)	Average Width of Channel (Feet)	Type of Bordering Vegetation and Lengths 1/	Width of Riparian (Feet)
Madera Canyon	Pima	1.0	6	OW-C-1 (1 mi.)	
Cienega Creek	Pima	8.5	10	R (5 mi.), G (6.0 mi.), D-2 (4 mi.)	900
Sonoita Creek	Santa Cruz	8.0	6	G (5.5 mi.), R (2.5 mi.)	300
Santa Cruz River	Santa Cruz	2.0	30	OW-C-1 (2.0 mi.), Being Developed for Urban (2 mi.)	
Cave Creek	Santa Cruz	4.0	6	OW-C-3 (1 mi.), OW-C-2 (3 mi.)	
Gardner Canyon	Santa Cruz	3.5	6	OW-C-3 (1 mi.), OW-C-2 (2.5 mi.)	
Madera Canyon	Santa Cruz	5.0	6	OW-C-1 (1 mi.), OW-C-2 (4.0 mi.)	
Babocomari River	Santa Cruz	1.5		G (1 mi.), R (0.5 mi.)	600

Source: Data compiled from several sources including U.S. Geological Survey Quadrangle Maps; A Plan for Outdoor Recreation for Arizona, June 1967; A Drainage Map of Arizona, Miller, R. R. 1954; and oral communications with Forest Service personnel.

1/ Types of Bordering Vegetation are coded as follows:

Type	Code
Riparian	R
Pine-Mixed Conifer	P-MC
0-30% canopy	1
31-60% canopy	2
61-100% canopy	3
Oak-Woodland Chaparral	OW-C
0-30% canopy	1
31-60% canopy	2
61-100% canopy	3
Desert	D
Chihuahuan	1
Sonoran	2
Largely Barren	3
Grassland	G

Page 2 of 2 pages.

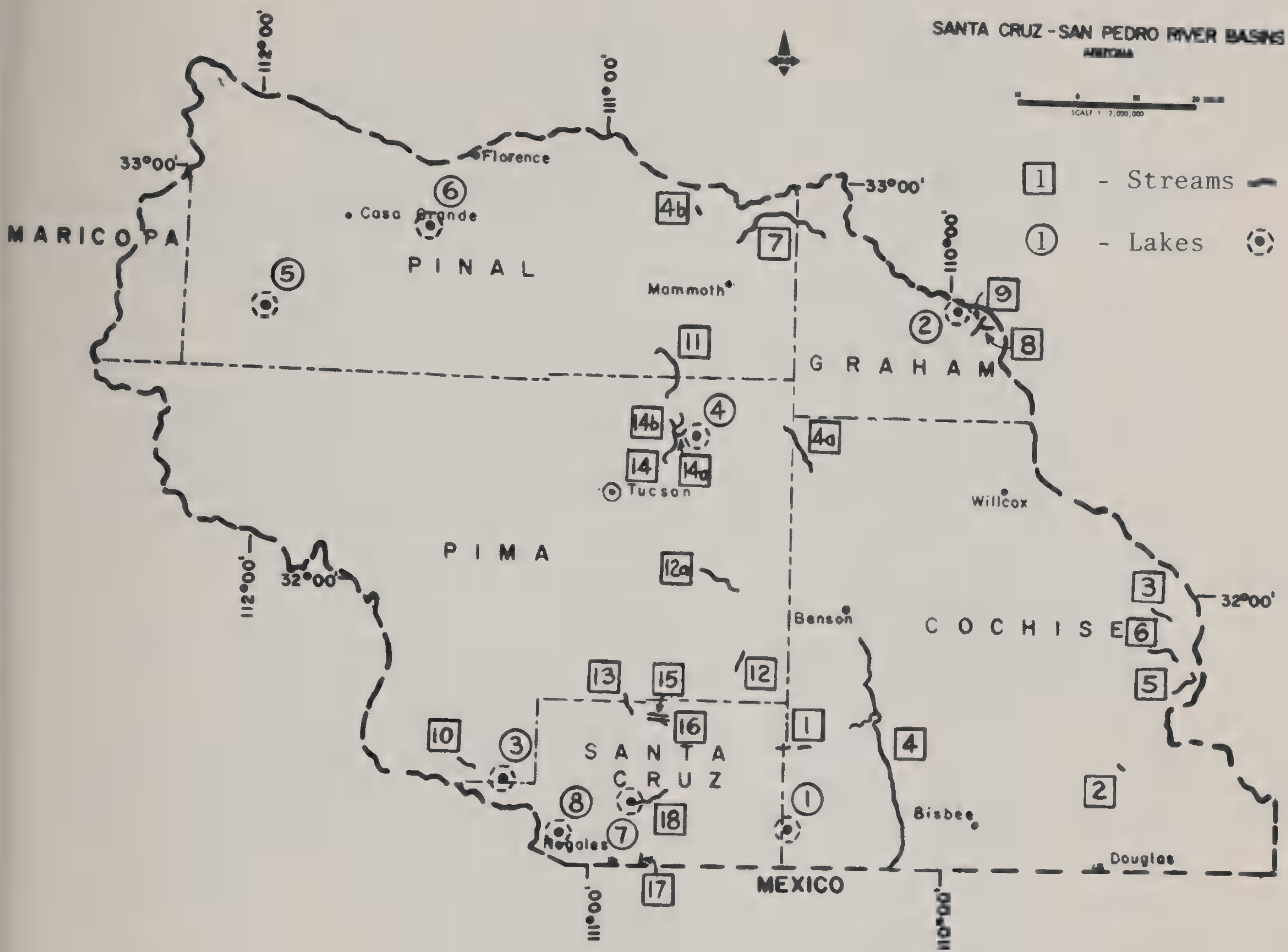


FIGURE 18 - Live Streams and Lakes in the Santa Cruz-San Pedro River Basins.

LIVE STREAMS AND LAKES BY COUNTIES

Stream No.	Stream Name	Lake No.	Lake [redacted]
	COCHISE COUNTY		
1	Babocomari River	1	Parker Canyon
2	Leslie Canyon		
3	Pine Creek		
4 & 4a	San Pedro River		
5	Rucker Canyon		
6	Turkey Creek		
	GRAHAM COUNTY		
7	Aravaipa Creek	2	Riggs Flat
[redacted]	Grant Creek		
9	Post Creek		
	PIMA COUNTY		
10	Arivaca Creek	3	Arivaca
11	Canada del Oro	4	Rose Canyon
12 & 12a	Cienega Creek		
13	Madera Canyon		
14	Sabino Canyon		
14a	East Fork Lemmon Canyon		
4a	San Pedro River		

Stream No.	Stream Name	Lake No.	Lake Name
	PINAL COUNTY		
7	Aravaipa Creek	5	Lake St. Clair
11	Canada del Oro	6	Picacho
4b	San Pedro River (Leroy Spring)		
	SANTA CRUZ COUNTY		
1	Babocomari River	7	Patagonia
15	Cave Creek	8	Pena Blanca
16	Gardner Canyon		
13	Madera Canyon		
17	Santa Cruz River		
18	Sonoita Creek		

Lakes and Impoundments

Surface water acres in the form of lakes and impoundments are limited. Of the total 10,560,400 acres in the study area, only 8,500 acres can be classified as surface water in lakes or impoundments. Approximately 40 percent of these surface water acres are in some 3,266 stock ponds or other small impoundments which are scattered throughout the study area. An additional 30 percent are in mine tailing reservoirs. The remaining 30 percent are the larger impoundments which are important from an aesthetic or environmental standpoint (Table 2.7).

The aesthetic quality of the larger lakes is generally more pronounced than the smaller ones. They provide more contrast with the surrounding flora and fauna. Two exceptions to this generalization are Rucker and Sabino, which are both smaller than five acres, but still have high aesthetic and recreational value. Although the smaller impoundments are generally not as attractive to humans, they are more important from a wildlife standpoint than the larger lakes. Because of wide distribution, the smaller lakes serve as an important source of water for wildlife. The larger lakes are more important as fisheries.

Water quality data for lakes, as for live streams, is scanty. However, some generalizations were made from observations and past use. Turbidity lowers the attractiveness of the water aesthetically and lowers the quality for fish habitat, wildlife consumption, and recreation. Turbidity levels in the lakes at the higher elevations are usually lower than the ones located in the desert. The larger lakes and the larger stock impoundments support fisheries sufficient for sport fishing. All of these bodies of water are used as drinking water by livestock and wildlife.

Ground Water 1/

Ground water is one part of the earth's hydrologic cycle. It is defined as that water which infiltrates the earth's surface, percolates downward, and is stored in the saturated zone of a geologic stratum. Water also occurs underground in unsaturated zones where voids are filled with water and air. In the study area, as in most of the southern part of Arizona, ground water is stored in alluvial filled basins. The alluvium consists chiefly of interbedded layers of Tertiary and Quaternary gravel, sand, silt, and clay (Table 2.2, p. 2.13a). The formations, groups of formations, or parts of a formation that contain sufficient saturated permeable material to yield significant quantities of water to wells and springs are called aquifers (12). Ground water occurs under both artesian (confined) and water table (unconfined) conditions in the many types of aquifers found in the study area. Figure 19, page 2.41, illustrates geologic conditions and the occurrence of ground water in a typical alluvial basin in the Santa Cruz-San Pedro River Basins.

1/ The basic descriptions for the ground water resources of the study area have been taken from publications of the U.S. Geological Survey. The data, however, have been updated to reflect the 1970 levels of development with inclusions of additional data developed by the Soil Conservation Service and the Arizona Water Commission.

TABLE 2.7

LAKES AND IMPOUNDMENTS IN THE SANTA CRUZ-SAN PEDRO RIVER BASINS

Name	Average Surface Acres	Use or Purpose
Cochise County		
Parker Canyon	125	Fish & Wildlife
Graham County		
Riggs Flat	10	Fish & Wildlife
Pima County		
Arivaca	90	Fish & Wildlife
Rose Canyon	7	Fish & Wildlife
Pinal County		
Lake St. Clair	2,000 1/	Flood Control, Irrigation
Picacho	50	Irrigation, Fish & Wildlife
Santa Cruz County		
Patagonia	260	Fish & Wildlife
Pena Blanca	45	Fish & Wildlife
Total for Basin	2,587	

1/ This is a newly constructed impoundment. The average size will be less than 2,000 acres, since water will be released for irrigation.

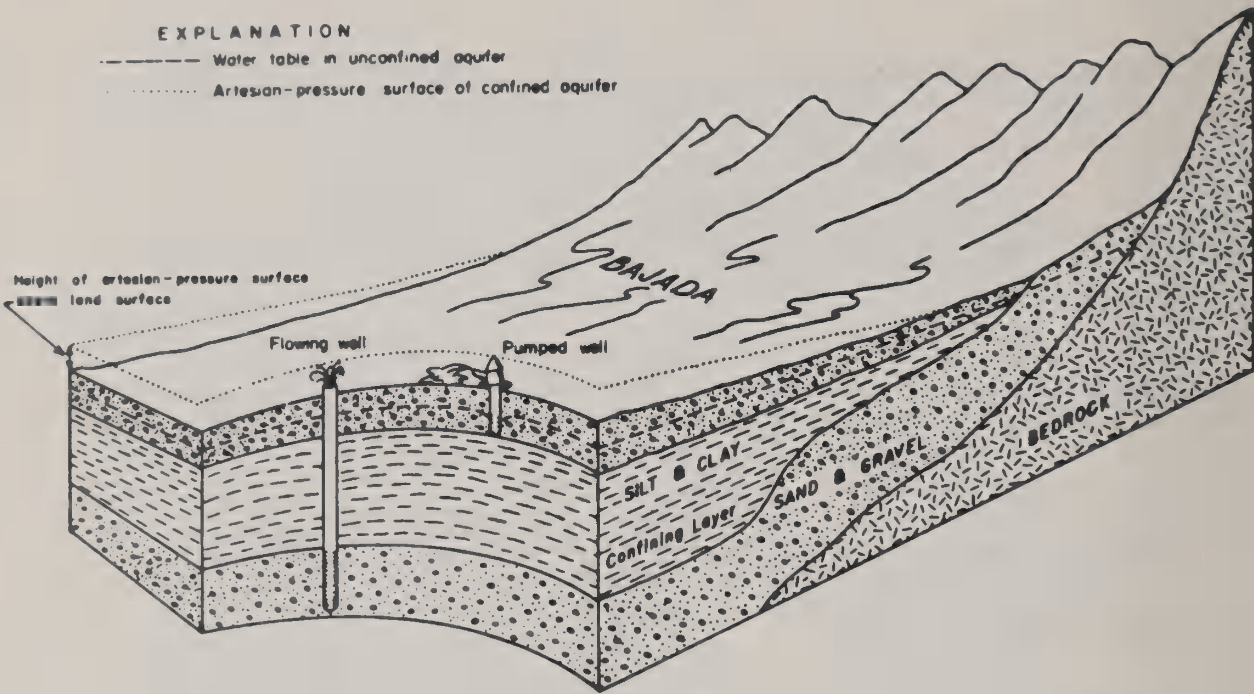


FIGURE 19 - General Geologic Conditions and Occurrence of Ground Water in a Typical Alluvial Basin of the Santa Cruz-San Pedro River Basins.

The direction and rate of movement of ground water through a saturated aquifer is influenced by three factors: (1) the hydraulic gradient, (2) the permeability of the material and, (3) the cross-sectional area of the saturated zone. Under water table conditions, ground water will move through material under the force of gravity down gradient. The slope of the water table in an area approximates, but generally is less than, the slope of the land surface except where it is controlled by subsurface barriers such as local cementation, clay layers, shallow hard rock, or fault zones that cause irregularities in the gradient of the water surface. Prior to development, the direction of movement of ground water in the alluvial basins of the study area was generally from the margins toward the axes of the basins and along the axes in the direction of the slope of the land gradient. The rate of movement of ground water in alluvial basins probably ranges from only a few feet per year to several thousands of feet per year. The most rapid movement probably is toward the axes from sources of recharge along the mountain fronts.

The ground water aquifers in the study area can be replenished from several sources: (1) infiltration of runoff from adjacent mountains, (2) direct penetration of precipitation on valley floors, (3) infiltration of waters used for irrigation, (4) water rising from depths as fault or fracture springs, and (5) underflow from outside the basin.

Although a large part of the precipitation that falls on the mountains adjacent to the valleys is lost to the atmosphere by evaporation or transpiration, a part becomes runoff and reaches the coarse alluvial materials at the mountain fronts where it may recharge the ground water reservoir. A large percentage of the surface runoff which reaches the main stream channels, also is infiltrated into the coarse channel bottoms and becomes a part of the ground water system. Refer to page 2.19 for a statement concerning infiltration of surface runoff in the main stream channels of Upper Santa Cruz River Basin.

Most of the precipitation that falls on the valley floor within the basin is evaporated directly from the soil zone or is transpired by vegetation. Only a small percentage percolates downward to the ground water reservoir. A portion of the water in canals and that applied to irrigate fields is returned to the ground water system. This process is referred to as incidental recharge.

Movement of ground water from depths within a basin can occur only where there is a confining layer between an upper and lower aquifer, and the lower aquifer is under artesian pressure. Under these conditions, any natural or artificial opening between the two aquifers, such as a fault or well field, will allow water to move from the lower aquifer to the upper aquifer. Thus, the upper aquifer is said to be replenished by water from the lower aquifer.

The ground water reservoirs in some basins are replenished by underflow from upstream basins through permeable materials underlying stream channels or through other areas not completely obstructed by the hard-rock barriers that usually separate the basins. This movement of water between basins replenishes the lower basin, but must be accounted for as discharge from the upper basin.

Other possible processes of discharge from the basins of the study area include: (1) evaporation, (2) transpiration, (3) spring discharge, and (4) pumping.

Small amounts of ground water may be discharged by direct evaporation where the water table is near the surface. In most of the study area, the water table is now sufficiently below the surface to prevent any significant amount of discharge in this manner. As the depth to water approaches ten feet, the discharge of ground water by evaporation becomes negligible.

Natural transpiration of water from the ground water reservoir is generally limited to that used by phreatophytes. These are plants that sink their roots to or below the capillary fringe and use ground water for their growth and sustenance. In many areas, these plants are quite dense, and they use thousands of acre-feet of ground water each year.

Ground water is discharged by springs where the water table intersects the land surface or where water from deep artesian aquifers finds an outlet through fractures or fault zones.

Large amounts of water are also discharged from aquifers through ground water pumpage. Estimates indicate nearly 2,000,000 acre-feet of water per year were withdrawn from the aquifers of the study area under normalized 1970 conditions. Additional description of these withdrawals is given in Chapter 4 in the "Water Use" section.

Although large volumes have been withdrawn, the aquifers of the Santa Cruz-San Pedro basins still retain vast quantities of ground water.

In order to calculate the amount of water stored in an aquifer, it is necessary to determine the volume of saturated material and the storage coefficient of the aquifer. The storage coefficient of an aquifer is defined as the volume of water an aquifer releases from or takes into storage per unit surface area of the aquifer per unit change in head, normal to that surface; thus, it is a dimensionless ration. The storage coefficients in the study area range from near zero for artesian condition to as high as 0.25 in some of the unconfined aquifers. The average for most basins is between 0.10 and 0.15.

Description of Basins

The study area has been divided into eleven ground water basins which conform to those used by the Arizona Water Commission in their cooperative studies with the U.S. Geological Survey (Figure 20). Table 2.2 (following page 2.13) provides a brief description of these basins. In most instances, the surface delineation for these basins follows the hydrologic boundary used in discussing the surface water resources of the area. The Santa Cruz and the San Pedro river basins, however, have been subdivided into seven ground water basins. The Santa Cruz River drainage area includes the Upper Santa Cruz, Lower Santa Cruz, Altar, and Avra ground water basins; and the San Pedro drainage area has been divided into the Upper San Pedro, Lower San Pedro and Aravaipa ground

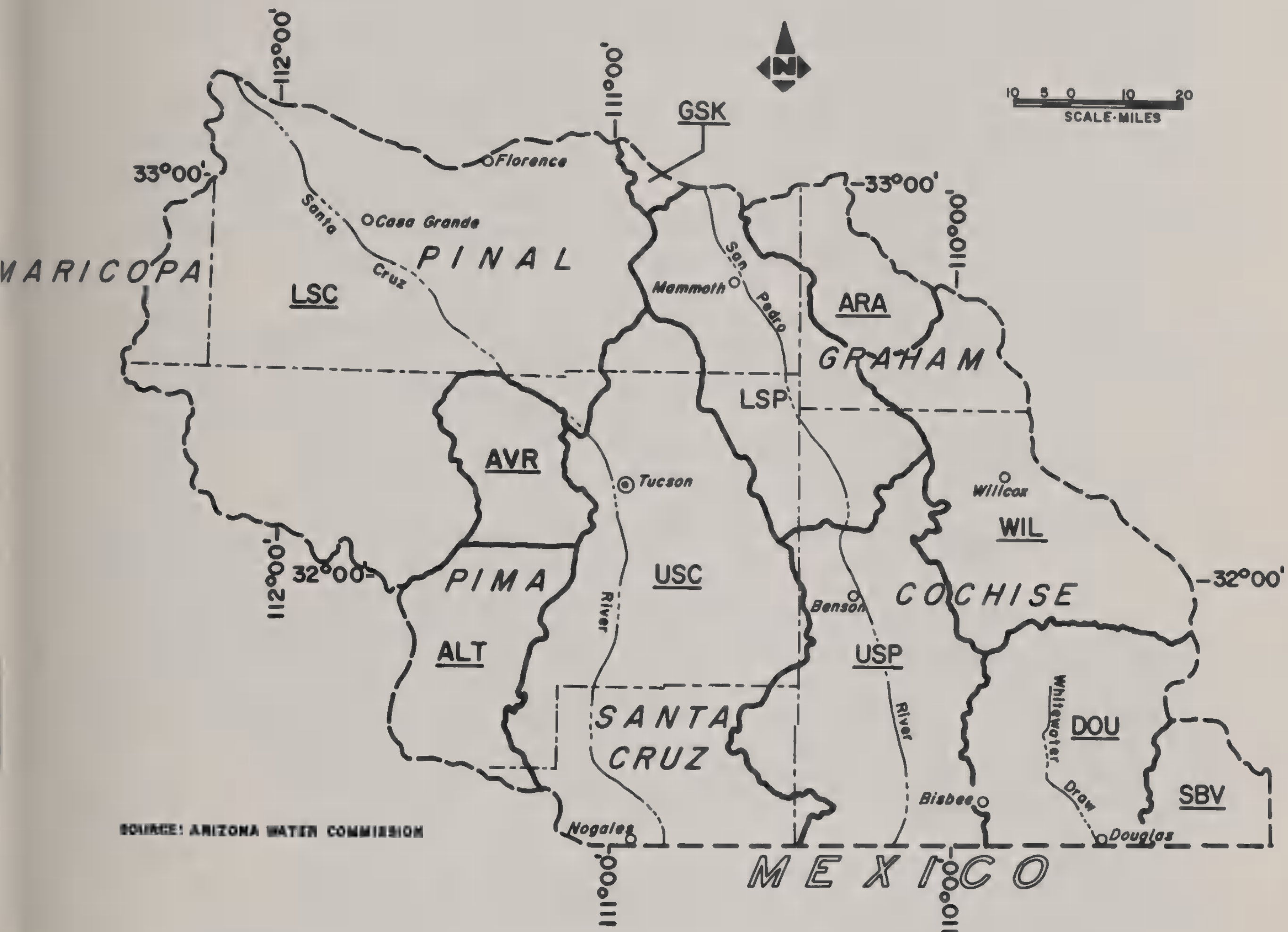


FIGURE 20 - Ground Water Study Areas in the Santa Cruz-San Pedro River Basins.

EXPLANATION

LSC - Lower Santa Cruz
USC - Upper Santa Cruz
AVR - Avra Valley
ALT - Altar Valley
LSP - Lower San Pedro
USP - Upper San Pedro

GSK - Gila River from Head of San Carlos Reservoir to Kelvin
ARA - Aravaipa Valley
WIL - Willcox
DOU - Douglas
SBV - San Bernardino Valley

water basins. Most of the Gila River surface water subarea, as described in surface water resources section, is included in the Lower Santa Cruz ground water basin. The remaining portion occurs in a small part of the ground water study area called Gila River from Head of San Carlos Reservoir to Kelvin (GSK).

The surface delineation for the Douglas, Willcox, and San Bernardino Valley ground water basins are essentially the same as those used in the surface water section of this report. Only in the reach between the Willcox and Aravaipa Valley basins do the surface and ground water divides not coincide. The ground water divide between these two basins lies south of the surface drainage divide.

The ground water resources for nine of the basins, in relation to development, are described in the following sections. Very little information is available concerning the ground water resources of the San Bernardino Valley basin (SBV) and the small portion of the GSK basin which lies within the study area. These areas will not be discussed further in this section of the report.

Upper Santa Cruz. This ground water basin is outlined on Figure 20 and includes three general areas where the thickness of alluvium is sufficient to store relatively large quatities of ground water. These are the Empire Ranch area located near Sonoita, San Rafael Valley in the upper reaches of the main stem of the Santa Cruz River, and the main stem of the Santa Cruz River from the International Boundary downstream to the Rillito Narrows. The ground water basins for the Canada del Oro and Rillito Creek tributaries are inter-connected with the main stem near Tucson and will be discussed in connection with this portion of the Upper Santa Cruz basin.

The Arizona Water Commission completed a study of the Empire Ranch area in 1972, focusing on the adequacy of water supply for a proposed community development of 42,000 people by GAC Properties, Inc. (This land has since been sold to copper mining interests). The results of this study, together with a discussion of the detailed procedures used in the analysis, are outlined in a study report entitled, "Study of the Adequacy of the Water Supply, Proposed Empire Ranch Development," dated July 7, 1972 (13).

The following description for the basin's ground water reservoir was taken from that report:

"The reservoir is comprised of an upper water table aquifer and an underlying artesian aquifer. The upper aquifer consists of Quaternary and Tertiary basin fill ranging in size from clays to sands and is overlain with recent stream alluvium in portions of the basin. Most wells drilled to date in this upper aquifer are low in production. Apparently, the unit is so low in productivity as to form the aquiclude confining the underlying artesian aquifer.

The lower aquifer consists of the Tertiary age, Pantano formation and the underlying Cretaceous sandstones, siltstones, and shales.

In the Tucson basin,[1] the 'Pantano is a light-to-medium reddish-brown, moderately cemented gravel...The unit contains granite and diverse types of sedimentary and volcanic detritus in an arkosic to clay-rich, sandy matrix.' Three of the six wells drilled for GAC Properties, Inc. bottom in a conglomerate within the Pantano formation, while the remaining wells bottom in the Cretaceous formations. The Pantano apparently is the most productive as those wells tapping a large saturated thickness of this formation are generally the best producers."

During the study, recharge for the Empire Ranch area was estimated to be about 5,000 acre-feet per year and was considered to occur along the mountain fronts. Since the basin is in an approximate state of equilibrium, the ground water discharge was assumed to be equal to the recharge. It is estimated that, under normalized 1970 conditions, approximately half the discharge was depleted by natural processes and was not available for use by man.

Storage coefficients for this portion of the Upper Santa Cruz basin are estimated to range from 0.001 for artesian conditions to about 0.05 under water table conditions. The total estimated volume of water stored in the Empire Ranch area is given on page 2.49.

Ground water data for the San Rafael Valley portion of the Upper Santa Cruz basin are very limited. Due to limited development in this area, data are not adequate to describe the ground water resources. An estimate, however, has been made of the total quantity of ground water in storage in the San Rafael Valley and is given on page 2.49. Recharge to the area is unknown but was considered ineffective under normalized 1970 conditions because most of recharge is lost through natural depletions.

The relatively flat, undissected portion of alluvial fill deposits in the main stem portion of the Upper Santa Cruz River basin is less than six miles wide at the upper end and from 12 to 18 miles near Tucson. All rock units in this portion of the basin are capable of storing and yielding water to wells or springs; however, the capability ranges widely from unit to unit and within a single unit. The rock units that bound the basin and form the mountains are mainly igneous, metamorphic, and tightly cemented sedimentary rocks. These rock units transmit and store smaller quantities of water than do the more porous, permeable, and loosely consolidated sedimentary rocks of the basin.

The lower main stem portion of the Upper Santa Cruz basin contains a series of interconnected sedimentary rocks which form a single aquifer. These rocks have been classified by the U.S. Geological Survey as four rock units based on their age and hydrologic characteristics. The units from the oldest to the youngest are: (1) Pantano Formation,(2)Tinaja beds,

1/ The Tucson basin is encompassed by and is an integral part of the Upper Santa Cruz basin as described in this report. The basin is described in USGS WSP 1939c (14) and is basically that part of the upper Santa Cruz basin lying between the Santa Cruz-Pima County line and the Rillito Narrows.

(3) Fort Lowell Formation, and (4) surficial deposits, which include the present-day alluvial-fan and stream channel deposits. Generally, cementation and compaction of the rock units increase with age and depth of burial. The dependent hydraulic factors such as permeability, porosity, and storage coefficient decrease accordingly.

The Pantano Formation has been previously described in connection with the Empire Ranch area. It is the least known part of the basin's aquifer, but because of its large volume and extent and moderate to high permeability and porosity, a knowledge of this unit is critical in regard to water resources management in the basin. Future drilling of deep wells into this formation will be necessary to confirm the facies distribution and to determine the areal distribution of well yields and storage potential.

The thickness of the Pantano Formation varies from a few hundred feet to over 10,000 feet. In most places, the permeability is great enough that a well tapping 500 to 1,000 feet of this unit has a specific capacity of at least 20 gallons per minute (gpm) per foot of drawdown, and some wells have specific capacities as much as 40 gpm per foot of drawdown. (The specific capacity of a well is the rate of discharge of water from the well divided by the drawdown of water level within the well due to pumping.) The yield of wells having diameters greater than 12 inches ranges from a few hundred to almost 5,000 gpm. Although no data are available to accurately define the storage coefficient of the Pantano Formation, the long-term yield probably is at least ten percent of the saturated volume in most of the basin (15).

The Tinaja beds overlie the Pantano Formation and are a major part of the aquifer. The beds are from less than 100 to more than 2,000 feet thick and grade from sandy gravel at the basin margins to gypsiferous mudstone, clay, and silt along the central part of the basin. Well yields vary from small to large, and specific capacities of wells range from about 1 to 40 gpm per foot of drawdown.

The Fort Lowell Formation is a locally derived sedimentary deposit that underlies most of the basin surface. This unit is the most productive part of the Upper Santa Cruz basin. The formation is from 300 to 400 feet thick in most of the basin and thins toward the mountains, towards the heads of Canada del Oro and Pantano Wash, and toward Rillito. The Fort Lowell Formation consistently contains more coarse material than does the Tinaja beds. In most of the basin, the Fort Lowell consists of 50 to 90 percent of material coarser than silt (more than 0.06 mm in diameter) and 25 to 60 percent of material coarser than sand (more than 2.0 mm in diameter)(15).

The sediment of the Fort Lowell is loosely packed to weakly cemented and ranges in color from dark to light reddish-brown. It is the most permeable unit in the Upper Santa Cruz basin aquifer and currently supplies most of the water used in the basin. The specific capacities of wells that yield water primarily from the Fort Lowell Formation range from 10 to 100 gpm per foot of drawdown. General potential well production for the Upper Santa Cruz basin is shown in Figure 21.

POTENTIAL WELL PRODUCTION
SANTA CRUZ - SAN PEDRO RIVER BASINS
ARIZONA

NOVEMBER 1974

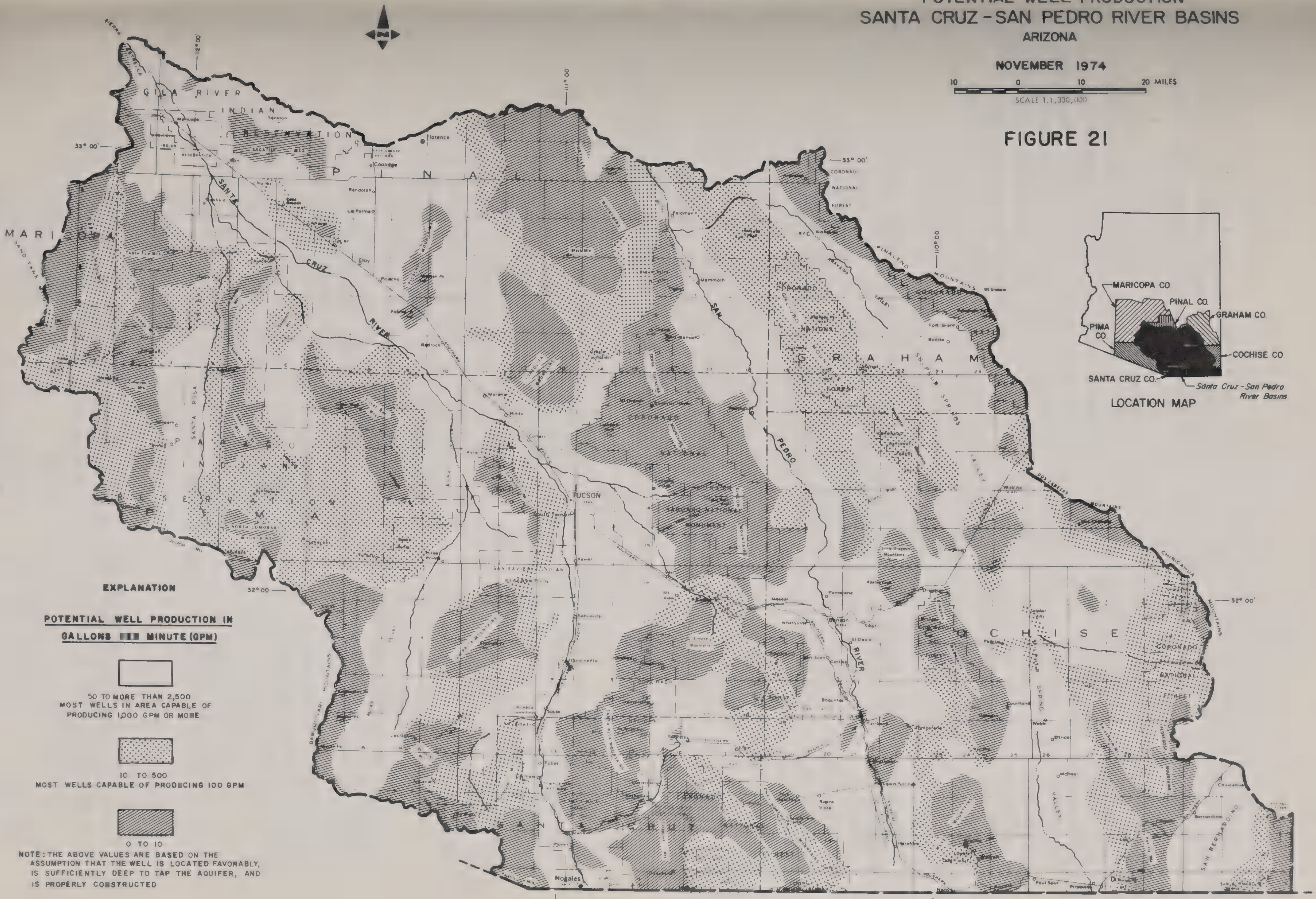


FIGURE 21

EXPLANATION

POTENTIAL WELL PRODUCTION IN GALLONS PER MINUTE (GPM)

- (blank) 50 TO MORE THAN 2,500 — MOST WELLS IN AREA CAPABLE OF PRODUCING 1,000 GPM OR MORE
- (dotted) 10 TO 500 — MOST WELLS CAPABLE OF PRODUCING 100 GPM
- (hatched) 0 TO 10

NOTE: THE ABOVE VALUES ARE BASED ON THE ASSUMPTION THAT THE WELL IS LOCATED FAVORABLY, IS SUFFICIENTLY DEEP TO TAP THE AQUIFER, AND IS PROPERLY CONSTRUCTED

SOURCE U.S. GEOLOGICAL SURVEY

U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE

The surficial deposits are mainly sand and gravel of fluvial origin and include alluvial fan, sheetflow, and stream channel deposits. The alluvial fan and stream deposits overlie and partially conceal all older sedimentary units and range from a thin veneer to tens of feet thick. These deposits are not significant with respect to the amount of ground water in storage because the water table is below these deposits nearly everywhere, and most rainfall is evaporated directly or is used locally by plants and is transpired. However, the alluvium is saturated along some reaches of Rillito Creek and along many of the small tributary streams. The stream deposits are very porous, and their present hydrologic function is to receive and store temporarily the infiltrated water from floodflow. Some of the infiltrated water replenishes the moisture demand of the stream alluvium and is soon transpired by plants along the stream, but most of this water is transmitted to the underlying aquifer.

The principal aquifers of the lower main stem portion of the Upper Santa Cruz basin are recharged mainly in two ways - by infiltration of runoff that reaches the main stream channels and by recharge along the mountain fronts. The basin's aquifers are also replenished by ground water that enter the basin as underflow from the valleys of Canada del Oro and Santa Cruz River. The total inflow to the basin from these sources, as estimated by the Soil Conservation Service and the Arizona Water Commission, is about 80,200 acre-feet per year. 1/ About 15,000 acre-feet of the volume, however, is discharged as underflow to the Lower Santa Cruz Basin at the Rillito Narrows, and about 2,700 acre-feet is depleted by riparian vegetation. The net effective recharge to this portion of the basin from natural flow is about 62,500 acre-feet per year.

Significant amounts of irrigation water and sewage effluent also are returned to the ground water reservoir. Replenishment from these two sources must be accounted for in a total water resource analysis of the basin. It has been estimated that approximately 30 percent of the total water pumped for irrigation in the Upper Santa Cruz basin is returned to the ground water system. This amounted to about 32,000 acre-feet under normalized 1970 conditions (Table 4.11, page 4.23). Recharge estimates from sewage effluent are difficult to obtain. This is due to the problem of separating sewage effluent recharge from natural streamflow infiltration occurring in the same reach. During analog model studies of the Tucson basin, the U.S. Geological Survey estimated that nearly 90 percent of the sewage effluent released to the streambed of the Santa Cruz River is returned to the ground water reservoir. Based on their studies, approximately 8,000 acre-feet per year was returned to the ground water reservoir during the period of 1960 to 1965 (15). The Arizona Water Commission estimated the total recharge from all municipal and industrial sources in the basin to be about 10,000 acre-feet per year (Normalized 1970 conditions, see Table 4.11).

1/ Data for the lower main stem portion of the Upper Santa Cruz Basin is based on the Arizona Water Commission and Soil Conservation Service ground water computer models.

An additional source of water supply in the Upper Santa Cruz basin is the importation of ground water pumped in the Avra Valley and transported to Tucson for municipal use. Under normalized 1970 conditions, this amounted to about 6,000 acre-feet per year.

The depth to water for all parts of the Upper Santa Cruz basin is shown on the Depth of Water Map, back of report. The depth to water along the river and tributary drainages is generally less than 100 feet; but only a few miles upslope, the depth to water may be several hundred feet below the land surface. The depth to water is greatest near the mountain fronts, the greatest occurring along the east side of the lower main stem portion and in the northern part of the Canada del Oro drainage basin. Depths to water in these two localities exceed 600 feet over several square miles of surface area.

The alluvium of the Upper Santa Cruz basin provides storage for large amounts of ground water. It has been estimated by personnel of the U.S. Geological Survey that approximately 51.4 million acre-feet 1/ of ground water are stored between the land surface and 1,200 feet below the land surface (16). About 33.4 million acre-feet, or nearly 65 percent of this volume, is stored between the land surface and 700 feet below the land surface.

Of the 51.4 million acre-feet, about 2.10 million acre-feet are in the Empire Ranch area and 0.57 million acre-feet are in the San Rafael Valley. The remaining volume of water stored in the Upper Santa Cruz basin is located along the main stem portion of the basin from the International Boundary to the Rillito Narrows and includes the Canada del Oro and Rillito Creek ground water subbasins.

Lower Santa Cruz. The boundary of the ground water basin is shown in Figure 20, page 2.44. The basin has a common boundary with the Upper Santa Cruz basin at the Rillito Narrows, and, except for Altar and Avra Valleys, includes the total drainage area of the Santa Cruz River basin below this point. There is, however, little data available to describe the ground water resources of Aguirre Valley and Santa Rosa and Vekol Washes. Hence, the major part of the remaining discussion will be limited to the area of the Lower Santa Cruz basin located north of the Silver Bell, Sawtooth, and Tat Momoli Mountains.

In general, the subsurface material of the Lower Santa Cruz basin is unconsolidated alluvial deposits underlain by consolidated alluvium and crystalline rocks. The mountains are composed of igneous, metamorphic, and sedimentary rocks. The igneous rocks are the more predominant rocks of the mountains. The unconsolidated alluvial deposits consist of interfingering layers of sand, gravel, silt, and clay, and have been classified and described as follows in "Mineral and Water Resources of Arizona," a report prepared by the U.S. Geological Survey, the Bureau of Mines, and the Bureau of Reclamation, 1969(5).

1/ The volumes of ground water in storage, as shown above differ from those shown in Table 2.9, Page 2.62. The major reason for these differences is given on page 2.64.

"In general, the unconsolidated alluvium can be divided into three units - the lower unit, the middle unit, and the upper unit. The lower unit consists of a heterogeneous mixture of sand, gravel, and clay. The unit is weakly to moderately cemented and yields large amounts of water to wells. The middle unit is composed of fine sand, silt, and clay and is the least permeable unit of the unconsolidated alluvium; generally, it yields only small amounts of water to wells. In places, the middle unit forms a confining layer; and water in the underlying more permeable unit is under artesian pressure. The upper unit is composed of unconsolidated sand and coarse gravel and has the highest average permeability of any of the units. Well yields generally are high, but the unit is being dewatered in large parts of the area because of large-scale pumping for irrigation."

The three units of the unconsolidated alluvium are the principal aquifers in the basin; and, except as noted above, the units combine hydrologically to form a single aquifer system in which ground water is under water table conditions. General potential well production from the aquifer system is shown in Figure 21.

Possible sources of recharge and/or replenishment include: (1) underflow to the area from adjacent basins, (2) seepage from natural flows, (3) precipitation on the valley floor, and (4) infiltration of water diverted for irrigation.

Underflow enters the Lower Santa Cruz basin from the Gila and Santa Cruz rivers and from Brawley, Santa Rosa, and Vekol Washes. The largest underflow to the basin occurs beneath the Santa Cruz River at the Rillito Narrows and is estimated to be 15,000 acre-feet per year. 1/ Underflow from Brawley Wash to the Lower Santa Cruz basin is estimated to be 8,000 acre-feet per year. Underflows from the other sources listed above are unknown but are considered minor in comparison to the Santa Cruz River and Brawley Wash underflows. Underflow out of the basin is estimated to be about 11,000 acre-feet per year and occurs beneath the Gila River at its confluence with the Santa Cruz River.

The principal areas where recharge from natural flows can occur are along the channels of the Santa Cruz and Gila Rivers and Brawley, Santa Rosa, Vekol, and McClellan Washes. Some surface runoff may also enter the ground water reservoir along the periphery of the basin where many desert washes enter the valley. The total recharge from natural flows, however, is thought to be minor, and was estimated only for the upper reaches of the basin.1/ Recharge from this source, from sewage effluent released into the Santa Cruz River at Tucson, and from other municipal and industrial sources has been estimated to be about 14,000 acre-feet per year under normalized 1970 conditions.

1/ All recharge and discharge estimates quoted for the Lower Santa Cruz basin were developed by the Arizona Water Commission during verification or projected runs of digital ground water model developed in connection with allocation studies for Central Arizona Project waters.

Recharge from direct precipitation on the valley floor in the Lower Santa Cruz basin is minimal in most years. The areas most favorable for receiving recharge from this source are those with five feet or more of coarse uncemented material underlying the surface. The gross area within the basin meeting this criteria is small. The amount of recharge from direct precipitation is correspondingly small.

The total volume of recharge incidental to irrigation in the Lower Santa Cruz basin was estimated to be about 354,000 acre-feet per year under normalized 1970 conditions (Table 4.11, page 4.23). This figure represents about 32 percent of the total water withdrawn for irrigation. The total withdrawal includes 197,000 acre-feet per year of surface water diverted from the Gila River into the Florence-Coolidge-Casa Grande area. Also about 23,000 acre-feet per year of ground water pumped in other basins were imported into the Lower Santa Cruz basin for irrigation purposes (normalized 1970 conditions). About 8,000 acre-feet were from Avra Valley, and 15,000 acre-feet were from the Upper Santa Cruz basin. Thus, incidental recharge from irrigation includes both canal losses and on-farm deep percolation losses.

The depth to water in the Lower Santa Cruz basin ranges from 50 feet to more than 600 feet below the land surface. (Depth to Water Map, back of report). Topography, geology, and areal concentration of pumping are the main factors that control the depth to water. Depth is shallowest in a small area west of Casa Grande and deepest along the edges of the valley near Stanfield.

The volume of recoverable ground water underlying about 1,323 square miles of the Lower Santa Cruz basin was calculated by the U.S. Geological Survey to be 59.5 million acre-feet (17). 1/ This volume of water is stored between the land surface and 1,200 feet below the land surface. About 55 percent, or nearly 33 million acre-feet, of this volume is stored between land surface and 700 feet below the land surface.

Altar and Avra Valleys. These valleys are in a north-trending trough that extends from a drainage divide about three miles north of the International Boundary to the valley of the Santa Cruz River at the Pima-Pinal County line (Figure 20, page 2.44). Alter Valley forms the upper part of the trough, and Avra Valley forms the lower part. The boundary between the two valleys is artificial, and the ground water basins in the area are interconnected and act as a single unit.

The major aquifer in the area consists of interfingering lenses of silt, sand, and gravel. These deposits are coarse and permeable and are capable of storing and yielding large amounts of ground water to wells. The alluvium is present to depths as great as 2,000 feet along the central parts of the valleys. Along the mountain fronts, however, bedrock underlies the alluvium at shallow depths, and there is less storage space for ground water. In general, water table conditions exist in the basin's aquifer to a depth of at least 700 feet. Below a depth of about

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1/ The volumes of ground water in storage, as shown above, differ from those shown in Table 2.9, page 2.62. The major reason for these differences is given on page 2.64.

1100 feet, there is some evidence that the water is confined beneath less permeable materials and that it may rise in wells above the regional water tables in places. Data are insufficient to determine the extent of the confined aquifer. Figure 21 shows the general potential well production from the saturated materials in the area.

The ground water reservoir in Altar and Avra Valleys are replenished by infiltration of runoff along the mountain fronts and from underflow at the head of the drainage. Some recharge may occur from floodflows in the main drainage channels. A portion of the water pumped for irrigation is also returned to the ground water system through infiltration along canals and in irrigated fields. The amount of recharge occurring in Altar Valley is not known, but it has been estimated that about 8,000 acre-feet of ground water per year 1/ is being discharged from the basin as underflow into Avra Valley (normalized 1970 conditions). Since Altar Valley has not been developed extensively, evidently most of the recharge to the basin is being discharged in this manner. Water levels in Altar Valley are declining, however, and part of the underflow from the basin results from water being withdrawn from storage.

In addition to receiving underflow from Altar Valley, the Avra Valley ground water basin is recharged by infiltration of surface water in the Santa Cruz River. The average annual recharge from this source is estimated to be about 4,000 acre-feet per year.

Incidental recharge from irrigation return flow is generally expressed as a percentage of the total water used for irrigation and, in Altar and Avra Valleys, has been estimated to be about 20 percent of the total water pumped for this purpose. Based on normalized 1970 pumpage figures, the average annual recharge from this source is estimated to be 28,000 acre-feet per year. (See Table 4.11, page 4.23).

In addition to withdrawals for irrigation, ground water is discharged from Avra Valley through basin export and as underflow northward to the highly developed Lower Santa Cruz basin. The underflow at the common boundary has been estimated to be about 8,000 acre-feet per year. 1/ The estimated export from the basin is 13,400 acre-feet per year (normalized 1970 conditions). An estimated 6,000 acre-feet of this is used for municipal purposes in Tucson, and 7,400 acre-feet is transferred to the Lower Santa Cruz basin for irrigation in the Cortaro-Marana area.

The depth to water in Altar and Avra Valleys varies greatly (Depth to Water Map, back of report). In Alter Valley, the depth to water generally is less than 200 feet below the land surface in the central part near Altar Wash but is more than 300 feet a short distance upslope from the wash. The water level is 680 feet below the land surface in a well about six miles upslope from the wash and slightly less than three miles from the base of the Sierrita Mountains. In Avra Valley, the depth to water is about 240 feet at the north end and about 350 to 400 feet in the center. Across the south end of the valley, within a distance of less than four miles, the depth to water ranges from 175 to more than 425 feet.

1/ Arizona Water Commission ground water model study for Avra Valley. (See footnote on page 2.50).

In a recent analysis by the U.S. Geological Survey, it was estimated that slightly more than 30.4 million acre-feet of recoverable ground water is in storage between the land surface and 1,200 feet below the land surface in the two basins (16).

This water is distributed with respect to basin and by depth below the land surface as follows:

Ground Water in Storage
(1000 Ac. Ft.)

Basin	0-700' Depth	700'-1200' Depth
Altar	6,450	6,160
Avra	7,790	10,020
Total	14,240	16,180

In general, the amount of recoverable ground water per square mile (to a depth of 1,200 feet) is greatest toward the center of the basins, where the saturated thickness is greatest, and decreases in a somewhat uniform manner toward the margins of the basins. Although the total volume of ground water shown above is in general agreement with that used by the Arizona Water Commission in the State Water Plan, the distribution by basin and by depth varies to some degree. 1/

Upper and Lower San Pedro River Valley. The valley is divided into an upper and lower basin at about its mid-point (Figure 20). The Upper San Pedro basin extends from the International Boundary to the Narrows, eleven miles north of Benson. The Lower San Pedro basin extends from the Narrows northward to the mouth of the San Pedro River at Winkelman. For the purposes of this discussion, however, the basins will be treated as one unit.

The rocks of the San Pedro River Valley have been divided into four basic groups by geologists of the U.S. Geological Survey (11). These rock units are listed in order of their increasing porosity and permeability and decreasing geologic age as: (1) the crystalline and consolidated sedimentary rocks, (2) the consolidated to semi-consolidated sedimentary rocks, (3) the valley-fill deposits, and (4) the flood plain alluvium. The flood plain alluvium and valley-fill deposits make up the principal aquifer in the valley. Only in local situations do the consolidated and semi-consolidated sedimentary rocks yield sufficient quantities of water for irrigation or other high water requirement purposes. The crystalline and consolidated sedimentary rocks generally yield only small amounts of water to wells.

The crystalline and consolidated rocks underlie the entire basin and generally are referred to as bedrock. They form the mountains which bound the valley on either side, and consist of crystalline granitic, igneous and metamorphic rocks, volcanic rocks, and consolidated sedimentary rocks. The consolidated sedimentary rocks include limestone, sandstone, shale, conglomerate, and a small amount of quartzite. the

1/ See footnote on page 2.51

water-bearing potential of this unit is small. The unit has a low primary permeability and porosity, and its ability to store large quantities of water is directly dependent upon the degree of fracture of the base rock. Springs that flow from this unit generally are small, and wells drilled into the unit yield only enough water for livestock or for small domestic supplies. There are a few large springs, however, located in the limestone beds of the Huachuca Mountains that yield several hundred gallons of water per minute. These springs have been used for many years as a supply or as a supplemental supply for domestic purposes by Fort Huachuca and Tombstone. In places, water in the crystalline and consolidated sedimentary rock unit is under artesian pressure.

The consolidated to semi-consolidated sedimentary rocks consist of tilted beds of gravel, gravelly sandstone, and conglomerate which grade into and are interbedded with mudstone and siltstone toward the center of the basin. The permeability is generally low. In places, fine grained beds, well cemented layers, and the overlying valley fill deposits act as confining layers; and water is under artesian pressure.

The valley-fill deposits consist of flat-lying beds of clayey and silty gravel, silt, sandy silt, gravel, sandstone, and siltstone. Wells that tap this unit may yield more than 1,000 gpm. These deposits are divided into an upper and lower part. The lower part varies in thickness from a few tens of feet along the sides of the valley to possibly more than 1,000 feet in the center of the valley. The upper part is from 300 to 800 feet thick in the area between Benson and the International Boundary, but erosion has removed most of the upper part of the valley fill in the northern part of the basin. In areas near Benson and St. David, ground water is under artesian pressure where saturated gravel layers of the lower part of the valley fill deposits are overlain by less permeable silt beds of the upper part.

The flood plain alluvium in the San Pedro River Valley is the most permeable aquifer in the valley. It consists of beds, lenses, and mixtures of gravel, sand, and silt along the channel and flood plains of the San Pedro River and its tributaries. The unit is narrow - from less than a mile wide to about three miles wide - and generally is from 40 to 100 feet thick, but may be as much as 150 feet thick in places. Gravel and sand are dominant and usually are uncemented. Water withdrawn from the unit is replaced quickly by infiltration of stream flow during periods of runoff. Wells completed in the flood plain alluvium are capable of producing more than 2,000 gpm. Most of the irrigation wells in the valley obtain their water from this unit. Figure 21 shows the general potential well production for the aquifers of the San Pedro River Valley.

The ground water reservoir receives recharge from runoff along the mountain fronts and from infiltration of stream flow as it traverses the San Pedro River and its tributary channels. The flood plain alluvium readily accepts recharge from the intermittent flow of the San Pedro River. The river, however, also serves as a major outlet for discharge of ground water moving toward the center of the valley from its sources of recharge along the mountain fronts. The total mountain front recharge

in the San Pedro River Valley is not known. Recharge from surface flow in the San Pedro River also has not been calculated, but available records indicate recharge to the flood plain alluvium along the San Pedro River and its tributaries has been sufficient to balance ground water effluent discharge, the use of ground water by phreatophytes, and withdrawals of ground water for irrigation purposes. Some of the land along the San Pedro River was occupied by phreatophytes before it was developed for irrigation. Therefore, one water use has been replaced by another.

The ground water reservoir in the San Pedro River Valley is also replenished by underflow at the International Boundary near Palominas. The total underflow at the boundary has been estimated to be 3,400 acre-feet per year (11).

The depth to water in the shallow wells along the flood plain of the river ranges from less than 20 to 85 feet below the land surface. (Depth to Water Map, back of report). Some of the artesian wells in the flood plain flow, but in other wells with artesian pressure water levels are as much as 50 feet below the land surface.

The Arizona Water Commission has estimated that approximately 63,000,000 acre-feet of ground water are in storage in the San Pedro River Valley to a depth of 700 feet below the land surface.(See Table 2.9). This volume is about equally distributed between the upper and lower San Pedro basins. The upper basin contains about 36,000,000 acre-feet and the lower basin about 27,000,000 acre-feet.

Between a depth of 700 feet and 1200 feet below the land surface, an additional 12,000,000 and 3,000,000 acre-feet are estimated to be in storage in the upper and lower basins, respectively.

Aravaipa Valley. From its headwaters in southwestern Graham County, Aravaipa Valley trends northwestward for about 30 miles to the head of Aravaipa Canyon. The relatively flat, undissected part of the valley fill ranges from less than half a mile to about one and one-half miles wide. The thickness of the alluvial deposits is not known. The chief source of ground water used in the narrow valley is the shallow alluvium along Aravaipa Creek. Generally, wells are less than 150-feet deep. A few deeper wells may produce some water from volcanic material. The permeable material underlying the valley will yield from 50 to more than 2,500 gpm (Figure 21), but most wells are not equipped to produce large amounts of water.

The ground water divide between Aravaipa Valley and the Willcox basin is south of the surface water drainage divide. In the area between the two divides, water levels in wells indicate the presence of a perched water body above the regional water table. The perched water table generally is less than 10 feet below the land surface, whereas the regional water table is from 200 to 400 feet below the land surface. The aquifer has not been penetrated below a depth of about 700 feet, but there is some evidence from drillers' logs that regional water is present in the Tertiary volcanics rather than in the alluvium. Nevertheless, there is probably a single regional aquifer, and ground water in the aquifer

moves from the divide area toward Aravaipa Creek and northwestward along the creek toward the San Pedro River. Ground water in the perched water body moves southeastward in the direction of the surface drainage and into the Willcox basin. Data is insufficient to determine the amount of ground water in storage in the Aravaipa Valley.

Willcox Basin. The Willcox basin trends northwestward and extends from the low lying hills about 20 miles south of Willcox to the headwaters of Aravaipa Creek (Figure 20).

The subsurface materials in the Willcox basin can be classified into two broad groups - the rocks of the mountain blocks and the rocks of the basin fill (Table 2.8). The rocks of the mountain blocks consist of igneous, metamorphic, and sedimentary rocks, and generally yield only small quantities of water to wells. The water-bearing characteristics of the mountain rocks depend primarily on their degree of weathering and fracturing. Small quantities of water for stock and domestic uses have been developed from wells drilled into the fractured and jointed zones of the mountain block formations.

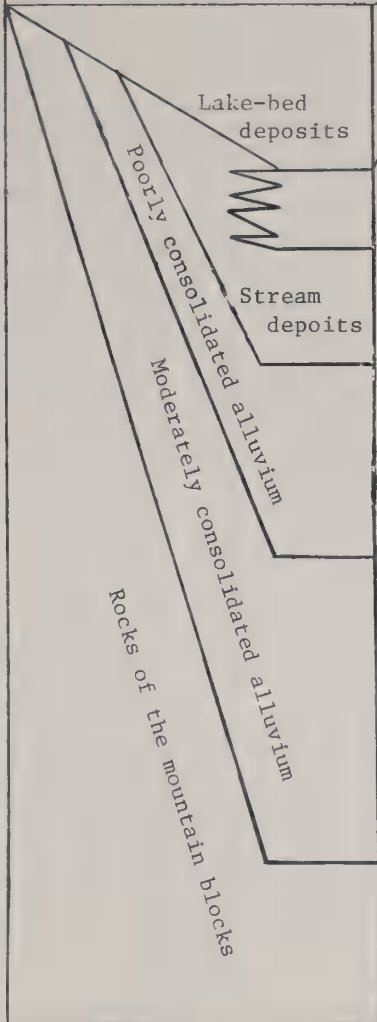
The rocks of the basin fill consist of consolidated and unconsolidated alluvium. The consolidated alluvium is further subdivided into moderately consolidated and poorly consolidated alluvium (Table 2 8). The moderately consolidated alluvium overlies the rocks of the mountain blocks and is overlain in most of the area by the poorly consolidated alluvium and unconsolidated alluvium.

The poorly consolidated and the moderately consolidated alluvium constitute the bulk of subsurface strata. Because these units have similar lithologic characteristics, they are difficult to differentiate in drillers' logs. Where the two units crop out, they are differentiated by the presence or absence of structural deformation.

The moderately consolidated alluvium has been deformed locally by tilting and by normal faulting, but not by thrust faulting. The poorly consolidated alluvium probably was deposited after the deformational activity had nearly ceased and was not deformed as intensely as the moderately consolidated alluvium.

The water-bearing characteristics of the consolidated alluvium are not well known, but it is felt that the fine-grained material and carbonate cement prevent it from readily yielding large quantities of water to wells. Along the edges of the basin, however, wells that penetrate only the coarse-grained facies of the moderately consolidated alluvium usually produce sufficient quantities of water for domestic and livestock purposes. The unconsolidated alluvium underlies most of the valley floor and consists of two facies - stream deposits and lakebed deposits associated with the old playa. The lenticular sand and gravel layers interfingered with the silt and clay-sized material constitute the principal aquifer in the basin and yield large quantities of water to wells. The lakebed deposits of the unconsolidated alluvium act as a confining layer, causing local artesian conditions near the Willcox Playa, especially on the east side.

TABLE 2.8
COLUMNAR SECTION, STRATIGRAPHIC TABLE, AND WATER-BEARING CHARACTERISTICS OF ROCK UNITS IN THE WILLCOX BASIN



Geologic Unit			Description	Water-bearing characteristics
Rocks of the basin fill	Unconsolidated alluvium	Lake-bed deposits	Black to gray clay and silt, locally overlain by thin beach gravel and sand dunes	Fine-grained materials have very low permeability and are not considered to be water bearing; may act as an important local confining layer in areas near the Willcox Playa
		Stream deposits	Pale-red to light-brown lenticular interbedded gravel, sand, silt, and clay	Sand and gravel beds in this unit are highly permeable and yield large quantities of water to irrigation and domestic walls; probably the most productive aquifer in the basin
		—UNCONFORMITY—		
	Consolidated alluvium	Poorly consolidated alluvium	Poorly indurated lenticular light-reddish-gray beds of sand, gravel, silt, and clay	Unit generally has low to moderate permeability; yields moderate to relatively large quantities of water to wells in the Kansas Settlement area if sufficient thickness is penetrated
		Moderately consolidated alluvium	Moderately indurated stream-deposited beds of gray conglomerate, sandstone, and mudstone materials composed of angular to rounded rhyolitic and andesitic volcanic fragments in a matrix of sand and fine-grained material derived from surrounding mountain areas; intercalated basaltic lava flows are deformed by tilting and normal faulting	Unit has very low to moderate permeability; produces small to moderate quantities of water sufficient for stock and domestic supplies
		—UNCONFORMITY—		
Rocks of the mountain blocks		Rocks of the mountain blocks	Igneous, metamorphic, and sedimentary units form the mountains and hills that ring the basin	Water-bearing characteristics are highly variable and depend on local geologic conditions; lithologic characteristics and high degree of structural deformation generally prohibit development of large water supplies from these rocks

Source: U.S. Geological Survey Water-Supply Paper 1859-F, p. F11. (18)

Saturated sediments of the Willcox basin are capable of yielding from 50 to 2,500 gpm to wells (Figure 21). Most irrigation wells yield from about 750 to 1,200 gpm, but some yield only about 200 to 400 gpm. A few of the irrigation wells are reported to yield as much as 2,000 gpm. In general, wells east of Willcox Playa and south of Willcox have the highest yields. The lowest yields are from wells near the playa. Although large quantities of water are stored in the sediments beneath the playa, they do not yield water readily to wells. This is due to the very fine texture of these sediments which consist mostly of lakebed deposits.

The agricultural economy of the Willcox basin is dependent almost entirely upon its ground water resources. Prior to extensive development in the basin, the ground water surface formed an elongated depression, with its lowest part being located at the Willcox Playa. The ground water reservoir was recharged by infiltration of runoff at the mountain fronts, and ground water moved toward the playa from all directions and was discharged by evapotranspiration from the surface of the playa and surrounding vegetation.

Since about 1940, farmland has been developed extensively in the area; and two large cones of depression have resulted from ground water withdrawal for irrigation. One cone of depression encompasses the city of Willcox and extends several miles northward, and the other includes the farmlands east of the playa and extends northward to a point about five miles east of Willcox. The Soil Conservation Service, using a digital computer model developed by the Arizona Water Commission, simulated the ground water reservoir for the Willcox basin. From the computer model it was determined that the reservoir still receives recharge at the mountain fronts estimated to be about 15,000 acre-feet per year. Most of the water now moves toward the areas of heavy pumping, and a lesser amount moves toward the playa. From the model it was also determined that the aquifers of the basin are replenished by infiltration of water applied for irrigation. Recharge to the basin from normal irrigation was estimated to be the difference between total pumpage for the basin and the estimated depletion losses such as crop consumptive use, evaporation, and non-beneficial consumptive use. Based on the computed data, it was determined that about 68 percent (195,000 acre-feet) of the water pumped for irrigation was depleted in some manner, and about 32 percent (93,000 acre-feet) was returned to the ground water reservoir under normalized 1970 conditions. (See Table 4.11, page 4.23).

During verification of the model for the period 1952-63 it was found necessary to add inflow to the basin in excess of normal mountain front recharge and recharge incidental to irrigation. An amount approximately equal to the pumpage in an 18 square mile area just east of the playa was added to the model. This area, located in townships 15 and 16 South, Range 25 East, has had ground water pumpage greater than 10,000 acre-feet per year with little or no water level decline. The possibility of the area being replenished by normal ground water underflow can be ruled out, because the water level in the area is generally higher than that of the surrounding area.

Recharge from heavier than normal irrigation return flow is a

possibility. The area lies in a low swale, and tailwater from an extensive area to the south and east must pass through the area before reaching the playa. No data, however, are available to support this conclusion.

Another possibility is that the water in the designated area is being replenished by water rising from depth. This theory is strengthened by the fact that artesian pressure exists in the area. During the development period, several flowing wells were present.

Discharge from the Willcox basin can occur by five possible processes. These are: evaporation, transpiration, underflow out of the basin, spring discharge, and pumping. Compared to pumping, the total discharge by the four other means is small and is estimated to be less than 11,000 acre-feet per year. The rate of pumping has been increasing since about 1940 and presently amounts to about 290,000 acre-feet per year (Normalized 1970). (See Table 4.11, page 4.23)

The depth to water in the basin ranges from less than 25 feet near the Willcox Playa to about 300 feet in the developed area east of the playa. The average depth to water in most of the area north of Willcox is about 130 feet (Depth to Water Map, back of report).

The aquifers in the basin store a vast amount of ground water. It has been estimated that the volume of saturated sediments from average 1970 water levels to a depth of 700 feet below the land surface is about 230 million acre-feet. A weighted value for the storage coefficient was calculated to be 0.12. 1/ Using these values, it was estimated that about 28 million acre-feet of ground water is available for use in the basin above the 700-foot level. An estimate of 45 million acre-feet was made by S. G. Brown, U. S. Geological Survey (18). The major reason for this difference involves storage coefficient and specific yield values used in the calculations. Brown used a value of 0.15 for the specific yield of the acquifer as compared to the above value of 0.12 for the storage coefficient. 2/ Brown estimated 300 million acre-feet of saturated sediments as compared to the above 230 million acre-feet. A minor portion of this latter difference can be acounted for, in that additional sediments have been dewatered in the period of time between the two estimates.

Douglas Basin. The ground water reservoir constitutes the major source of water in the Douglas basin (see Figure 20, page 2.44 for location of the basin). Ground water supplies have been developed in the valley fill, in some of the hard rocks underlying the valley fill, and in local areas of hard-rock exposures located along the perimeter of the valley. The major aquifers of the basin, however, are located in the valley fill deposits. These alluvial deposits consist of permeable lenses of sand

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1/ The values for the volume of saturated sediments and storage coefficient were developed during ground water and model studies by SCS.

2/ In an unconfined water body, the storage coefficient is virtually equal to the specific yield. Although artesian pressures have been noted in the Willcox basin, water table conditions were assumed for the above calculations.

and gravel interbedded with layers of silt and clay. The alluvium underlies about 500 square miles of valley floor and is present to depths of more than 750 feet in the central part of the basin. The alluvium in the Douglas basin is capable of yielding from 50 to more than 2,500 gpm to wells (Figure 21). Most of the irrigation wells in the basin produce from 200 to 1,200 gpm. In most areas, the ground water in the alluvium is unconfined, but there are few places where water is under artesian pressure. The water table aquifer provides most of the ground water used in the Douglas basin. Therefore, the occurrence of artesian conditions will not be discussed further.

The ground water reservoir is recharged from runoff along the mountain fronts and from occasional floodflows in the upper reaches of Whitewater Draw. The only other known occurrence of significant replenishment is in the vicinity of Turkey Creek along the surface water divide that separates the Douglas and the Willcox basins (Figure 20, page 2.44). While Turkey Creek lies within the Willcox basin, part of the water which infiltrates into its alluvium eventually moves as underflow into the Douglas basin.

The hard-rock barriers that separate the Douglas basin from other basins to the east and west effectively prevent movement of ground water between these basins. The average annual recharge to the Douglas basin from all sources except irrigation return flow is estimated to be about 13,000 acre-feet. 1/ This volume includes 2,000 acre-feet derived from municipal and industrial return flows.

Irrigation return flow, although not adding any new water to the ground water system, must be accounted for in the total water resources inventory for the basin. Recharge incidental to irrigation was estimated in a manner similar to that used for the Willcox basin (i.e., the difference between total pumpage for irrigation and depletion requirements) and was estimated to be about 33,000 acre-feet per year, or 35 percent of the normalized 1970 irrigation pumpage. Also, about 6,000 acre-feet per year (normalized 1970) was pumped in the Upper San Pedro basin and transferred to the Douglas basin for use in the Bisbee area.

Ground water is discharged from the basin in the form of effluent seepage in the lower part of Whitewater Draw, as underflow at the International Boundary, and as ground water pumpage. When compared to the annual pumpage, effluent seepage and underflow out of the basin account for only a small percentage of the total average annual discharge.

In the central part of the basin, water levels range between 40 and 60 feet below the land surface (Depth to Water Map, back of report). Along the east side of the basin, the depth to water is more than 200 feet; and along the west side near the mountain fronts, the depth is more than 160 feet.

The thickness of alluvial material where water can be stored varies from less than 250 feet near the mountain fronts to more than 750 feet in

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1/ SCS Ground Water Model Study, 1974 and Arizona Water Commission Study for State Water Plan.

the central part of the basin. However, due to the insufficient depth-to-water data for the outlying areas, only the area in the central part of the basin has been used in calculating the amount of sediment available for the storage of ground water. This includes an area of about 190,000 acres where the sediment is more than 750-feet thick. The total volume of saturated material which is below the water table and above the 750 feet of depth is about 120 million acre-feet. Based on this volume and an average storage coefficient of 0.14 1/, about 17 million acre-feet of water is available from storage in the Douglas basin where the sediment is greater than 750-feet thick. In addition, a few million acre-feet of water probably are available where the alluvium is less than 750-feet thick.

Summary

Table 2.9 presents data for ten of the eleven ground water basins in the study area. This table was developed by the Arizona Water Commission for use in the State Water Plan, and summarizes the total dependable water supply and the amount of ground water in storage for each of the ground water basins. The table was developed from several sources of information and includes comment on the availability and sufficiency of data. Vacant cells indicate that no data were available for the particular element, zero indicates that no significant activity is estimated for the area, and the alphabetical code following a number relates the general level of confidence associated with the value presented. "G" indicates reasonably good information and the probability that the actual value is within plus or minus 15 percent of the estimated value, "F" indicates that the data base is only fair and that the estimate is probably within 25 percent of the actual value, and "P" indicates poor information and a good possibility that the actual value might vary more than 25 percent from the listed estimate. Where no alphabetical code accompanies a number, the number was derived from other values or other data. The table can be keyed to Figure 20, page 2.44, which shows the locations of the ground water basins.

The Water Commission, in their analysis, classified all ground water basins in the state into four categories. These categories are based on the level of available information and the ability to estimate the various elements in the table from a water balance analysis. Category I basins are those where estimates may be made for all elements. Category II includes all basins where the total withdrawals may be estimated,

1/ The storage coefficient of 0.14 was estimated by the Soil Conservation Service during ground water model studies. A value of 0.20 is estimated by the U.S. Geological Survey (USGS) and published in Water-Resources Report No. 30, "Hydrologic Conditions in the Douglas Basin, Cochise County, Arizona," May 1972, p. 25 (19). Using the higher value for the storage coefficient, and the 120 million acre-feet of saturated sediments, an estimated 24 million acre-feet of water would be available from storage in the areas where the depth of sediments is greater than 750 feet. This latter value was used by the Arizona Water Commission in the State Water Plan for a depth of 700 feet. (See Table 2.9).

TABLE 2.9 DEPENDABLE WATER SUPPLY AND GROUND WATER IN STORAGE BY BASIN IN THE SANTA CRUZ-SAN PEDRO RIVER BASINS 1/

UNITS: 1000 Acre-Feet

	BASIN	Category 2/	DEPENDABLE SUPPLY				Ground Water in Storage	
			Surface Water Diverted (1)	Natural Ground Water Recharge (2)	Basin Import (3)	Total [(1)+(2)+(3)] (4)	0' to 700' (5)	700' to 1200' (6)
AVR	Avra Valley	I	0	4	0	4	9,800	6,200
DOU	Douglas Basin	I	-	11	6F	17	24,000	7,600
LSC	Lower Santa Cruz Basin	I	197G	23	23G 3/	243	48,800	42,300
USC	Upper Santa Cruz Basin	I	0	65	6G 3/	71	28,000	28,000
WIL	Willcox Basin	I	0	15	0	15	43,000	11,000
ALT	Altar Valley	II	0	-	0	-	11,000	4,000
ARA	Aravaipa Valley	II	-	-	0	-	-	-
LSP	Lower San Pedro	II	-	-	0	-	27,000	3,000
USP	Upper San Pedro	II	-	-	0	-	36,000	12,000
SBV	San Bernardino Valley	IV	0	-	0	-	-	-

1/ The letter following the numbers indicate the range of probable accuracy: G is Good with ± 5-15 percent error; F is Fair with ± 15-25 percent error; and P is Poor with greater than 25 percent error. The dashes indicate probable but unknown values; zeros indicate withdrawals probably do not occur or are small with respect to the total withdrawal.

2/ The category designations were developed by the Arizona Water Commission and are defined as follows:
Category I: Sufficient data available to prepare fairly reliable estimates of water balance.
Category II: Areas where estimates may be made for total withdrawal. Information largely limited to data on use. Other values shown are based on judgments not supported by detailed data.
Category IV: Areas where data is sparse and depletions are believed to be less than 1000 acre-feet.

3/ Import is from pumping in an overdrafted ground water basin.

but insufficient data are available to reliably estimate all other elements. Category III contains those basins in the state in which significant water use occurs, but data limitations preclude making estimates of total withdrawals. In the Santa Cruz-San Pedro Study Area, there are no ground water basins that fall within this category. In Category IV basins little data are available, but this deficiency is not serious because of limited economic activity and rates of water withdrawal that probably do not exceed one thousand acre-feet per year.

Column 1 in the table shows the data related to surface water supplies. In some areas, surface water may be physically present but unavailable for diversion because of existence of prior downstream rights.

Column 2 in the table shows the estimated ground water recharge in terms of the amounts which occur naturally within the basin. The values presented, however, represent only the effective recharge to the ground water reservoir, i.e., total natural recharge less any natural depletions such as underflow out of the basin, phreatophyte use, etc.

Column 3 shows water imported to the basin from other areas. The source of this water is ground water pumping. In two basins, Upper Santa Cruz (USC) and Lower Santa Cruz (LSC), the basin import is from ground water pumping in basins that are being overdrafted. Basin imports to an area must also appear as basin exports from some other area. (See Column 1, Table 4.11, page 4.23).

Total dependable supply estimates are shown in Column 4 (regardless of incidental recharge). These estimated amounts could be withdrawn without overdrafting the ground water basin. This does not imply that changes would not occur in ground water levels during a short period of time. During periods of below normal rainfall and runoff, the surface water supplies and natural recharge will be less than the values shown. During wetter-than-normal times, the surface water supplies and natural recharge will exceed the values shown. The estimates shown for total dependable supply represent long-term averages and consist of surface water available for beneficial use (Column 1), natural recharge to the ground water reservoirs (Column 2), and basin import (Column 3).

In the Upper and Lower Santa Cruz, Douglas, Willcox and Avra Valley ground water basins, the total dependable supply has been estimated to be 349,000 acre-feet per year. Over half of this volume is derived from surface water diversions from outside the study area. This volume is insufficient to meet depletion requirements in the basins and has resulted in large overdrafts of the ground water reservoirs. (See Table 4.11, page 4.23).

The total dependable supply for the other basins listed in the table is unknown. Only limited developments have occurred in these areas, however, and since no large overdrafts have been experienced, the recharge to the ground water basins is estimated to be approximately equal to the depletion requirements.

The total volumes of ground water in storage in the basins (Columns 5 and 6), are those used by the Arizona Water Commission in the State Water Plan. Volumes were estimated by the U.S. Geological Survey (USGS) during the Lower Colorado Region Comprehensive Framework Study, 1970, and differ to some extent from those quoted in the foregoing descriptions. The data quoted in the descriptions for the Upper Santa Cruz, Lower Santa Cruz, Altar Valley, and Avra Valley ground water basins were taken from a publication recently completed by the USGS entitled: "Map Showing Distribution of Recoverable Ground Water in the Tucson Area, Arizona, " by W. R. Oskerkamp, 1973. (16)

Similar conflicts in storage data can be noted in the descriptions of the other basins and those listed in the table. The major reason for these conflicts is in the inability to accurately determine the specific yields (and/or storage coefficients) and the volume of saturated sediments to be used in respective computations. Since data are inadequate to make reliable estimates of these parameters, the volumes of ground water in storage used in the various studies have been given for comparison purposes. Generally, the more recent data are quoted in the narrative and can be compared to the data used by the Arizona Water Commission and shown in Table 2.9.

Water Quality

General

Water pollution control efforts by the State of Arizona and the federal government, until recent years, were concerned almost entirely with protection of the public health. Water pollution and quality-control problems were not major considerations in development of land and water resources. Thus, the issue of water quality was recognized as a major item to be studied at the time this study began. Consequently, studies and investigations in water pollution were initiated. However, these studies were only in infancy when Congress passed two major acts dealing with water pollution. These are the Federal Water Pollution Control Act Amendments of 1972 (Public Law 92-500) and the U.S. Safe Drinking Water Act of 1974 (Public Law 93-523).

Public Law 92-500 is a far-reaching complex law. Many of the prescribed standards, regulations, and guidance documents have been and still are undergoing repeated revision. Specific provisions within the act have been subject to litigation and different interpretations. To a lesser degree, the same may be true for Public Law 93-523. Because of this conflict in timing between these two acts and this study, it became apparent that a full realization of water quality could not realistically be included as part of this study. Therefore, the subject of water quality was dropped as a specific study item. However, some data has been developed.

It is hoped that the data which is presented may be helpful to federal, state, and local agencies involved in water quality planning at this time.

Surface Water

Information on the quality of surface water in the San Pedro study area is shown in a Public Law 92-500, Section 303 report, titled Water Quality Management Plan-Upper Gila and San Pedro Basins, January 1976, by URS Company

The quality of surface water in the Santa Cruz study area will be covered by the Public Law 92-500, Section 208 studies currently being conducted by the regional councils of government.

Section 208 of Public Law 92-500 requires that implementation plans be developed for reducing pollutants from all sources. The main thrust will be the control of non-point or diffused sources of pollution. As of this writing, the preparation of the Section 208 plans is in its infancy. The publication "Arizona's Continuing Planning Process for Water Quality Planning," Office of the Governor, State of Arizona, April 1976, fully explains the state's approach to implementation of Section 208.

The regional councils of government (COG's) have been designated as the agencies responsible for developing the plans. The boundaries of the COGs follow political, not hydrologic, boundaries. The COGs are to develop agreements with each other to assure coordination of planning efforts where COG boundaries cut across hydrologic boundaries.

The preparation of the Section 208 plans for the San Pedro study area will involve three COGs: Southeastern Arizona Governments Organization (SEAGO); Pima Association of Governments (PAG); and Central Arizona Association of Governments (CAAG). The preparation of the Section 208 plans for the Santa Cruz study area will involve four COGs: the three listed above the San Pedro study area plus the Maricopa Association of Governments (MAG).

The Governor's Office will use the Office of Economic Planning and Development, an executive agency, for the purpose of program administration, monitoring, coordination, incuring integration through the Integrated Grant Administration Program, and assisting in resolving potential conflicts among area wide water quality plans. There are numerous other agencies and entities with responsibilities. These include the Arizona Department of Health Services, the Arizona Water Quality Control Council, the Governor's Advisory Council on Intergovernmental Relations, and the State Planning and Coordinating Committee. The Governor's Office has overall responsibility for incuring the adequacy of the 208 Program.

The Arizona Water Quality Control Council has full statutory responsibility with regard to the setting of water quality standards

(except for drinking water) for surface water and for shallow groundwater where the groundwater acquifer is fed directly by surface water.

The surface waters of the basin generally contain low concentrations of dissolved solids and are of low sodium hazard. The mean soluble salt content of the Gila River at Kelvin, however, is about 900 mg/l. Peak nitrate concentrations of 23 and 77 mg/l have been noted at this point (24).

Rapid runoff from thunderstorms results in short duration, sediment laden flows. Because most of the streams of the study area are either ephemeral or intermittent, sediment loads are transported during only a very small fraction of the time. Much of the sediment does not affect water quality of perennial streams because most perennial streams are located in mountain areas where sediment production is low. One noted exception is the large volume of sediment transported by the San Pedro River to the perennially flowing reach of the Gila River between the San Carlos Reservoir and the Ashurst-Hayden Diversion. High concentrations of suspended and bedload sediment in the San Pedro River result from highly active valley dissection, which evidently began in the late 1800's. At Charleston, in the upper reaches of the river, a maximum daily suspended sediment concentration of 30,600 mg/l was measured by the U.S. Geological Survey in July 1966. In the mid reaches near Benson, the maximum recorded concentration was 78,600 mg/l in July 1969. Near the mouth, at Winkelman, a maximum daily suspended concentration of 123,000 mg/l was measured in August 1970.

The mineral quality of the Gila River declines considerably between its upper reaches and the mouth of the San Pedro River. At this point, erratic flows of the San Pedro with its lower concentrations of dissolved solids, serve to lower the mineral content of the Gila.

The biological quality of surface waters in the study area is generally good. Exceptions are local areas downstream from small communities and heavily used recreation areas.

Ground Water

The State of Arizona has not established standards for ground water, but the Office of Water Quality Control, Department of Health Services, has initiated a state ground water quality strategy. A ground water monitoring program is being developed. This program will help define and quantify the extent of ground water pollution problems, provide information about potential pollution, and provide support for surveillance and a possible permit program.

The subject of ground water quality in an arid setting is complex. It is not fully understood to what degree surface pollutant sources contaminate deep underground water supplies.

Alluvial deposits in the basins contain ground water with concentrations of dissolved solids ranging from less than 100 to about 7,000 milligrams per liter (mg/l). The most signigicant influence on ground

water quality is the mineralogical makeup of the deposits in which the water occurs. As a result, abrupt changes occur in the ionic makeup and concentration of dissolved solids both horizontally and vertically.

The suitability of water depends primarily on the intended use. The Public Health Service (USPHS) Drinking Water Standards recommended a maximum dissolved solids concentration of 500 mg/l. However, people in many parts of the study area have adjusted to higher concentration with no ill effects. Water containing up to 2,500 mg/l is generally considered acceptable for livestock. Industrial limits depend on specfic use and ionic makeup of the water, and maximum limits run from 500 to 1,500 mg/l. Depending on the ionic makeup of dissolved solids, the permeability of the soil, and the salt tolerance of the crop grown, concentrations up to 1,500 mg/l may be used satisfactorily for irrigation.

Generally, the concentrations of dissolved solids in ground water of the study area are less than 1,000 mg/l. Higher concentrations occur in all the alluvial basins, particularly in some zones in the vicinities of Tucson, Casa Grande, Coolidge, Winkelman, and Willcox.

Drinking Water

The Bureau of Water Quality Control, Arizona Department of Health Services, is responsible for surveillance of water supplies and for the States's compliance with the Federal Safe Drinking Water Act of 1974 (Public Law 93-523).

Water quality testing by the State is concentrated primarily in testing for bacteriological quality. There is a lack of complete chemical data for the Santa Cruz-San Pedro River Basins.

A summary for five elements, in relation to concentrations considered detrimental to human health, is shown on the map, Well Water Quality for Domestic Use. This map was developed by consolidation of data from fourteen different water quality reports. The primary report was "The Quality of Arizona'a Domestic, Agricultural, and Industrial Waters" by G. R. Dutt and T. W. McCreary. This report is considered to be the most extensive investigation conducted to date on the chemical characteristics of water in Arizona. The limits as shown on the map for chloride, fluoride, nitrate, and lead are as recommended by the USPHS in the 1962 standards. The limit for sodium is that proposed by Anon, Faulusch, and McCammon.

The data shown on the map are only a summary of selected wells and does not indicate detrimental concentrations in existing drinking water supplies. The map is included in this report only to record and present the data collected. The map was prepared prior to the passage of the Federal Safe Drinking Water Act. The reader is referred to the U.S. Environmental Protection Agency and the Arizona State Department of Health Services for current and detailed information on the quality of drinking water in the basin.

The major known problems with drinking water in the area involve total dissolved solids, sodium, lead, nitrate, chloride, and fluoride in ground water. High total dissolved solids (TDS) is the normal situation in desert areas. Generally, the TDS are less than 1,000 milligrams per liter. The main problem in the San Pedro study area is high fluoride concentrations in the Willcox area and along the San Pedro River.

A very low flouride concentration helps prevent tooth decay. During the formation of children's teeth, however, high flouride levels can caous mottling of teeth.

The main problems in the Santa Cruz study area are lead in areas south and northeast of Tucson, nitrate build-up in the ground water at Marana, high sodium levels in some wells in the Lower Santa Cruz Basin and the Tucson vicinity, and excessive chloride content in a substantial number of wells in the Lower Santa Cruz Basin. The source of the nitrate is wastewater discharges from Tucson into the Santa Cruz river bed upstream from Marana.

Lead is a cumulative toxin to the human body and accumulates in the bone. Lead is taken into the body through food, air, and tobacco smoke as well as drinking water. The drinking water standards for lead reflect the maximum allowable concentrations in domestic waters that contribute to the total toxic level by all intake means.

Excessive nitrate can harm infants and embryos and result in methemoglobinemia, or "blue baby". There have not been any documented cases of this within the basins.

High sodium levels may be harmful to people suffering from cardiac, renal, or circulatory deseases. Even low chloride content may by harmful to people suffering from heart and kidney diseases.

Irrigation Water

The sodium salinity hazard for irrigation water is shown on the map, Well Water Irrigation Classification. This map was developed from consolidation of data from thirteen different reports on water quality.

Most of the ground water used for irrigation in the study area has low sodium and medium to high salinity. Sodium, chloride, bicarbonate, and sulfate ions are harmful to plants when present in sufficient amounts. High levels of sodium may affect soil structure, restricting the movement of air and water. The sodium hazard may be expressed by the sodium absorption ratio, which is determined using the equation:

$$SAR = \frac{Na^{+}}{\sqrt{(Ca^{++} + Ma^{++})/2}}$$

To classify irrigation water, the SAR and the electrical conductivity (an indication of total dissolved solids) may be entered on the chart which is included on the Well Water Irrigation Classification Map. The chart, along with the following description of irrigation water classes, is taken from USDA Handbook No. 60 (23). As shown on the map, significant sodium and/or salinity hazards exist in the Casa Grande, Stanfield, and Tucson areas. Other problem areas tend to be isolated.

C1-S1 Low Salinity-Low Sodium Water: Waters in this class can be used with relative safety for irrigating any crop. It may be necessary to leach soils of low permeability occasionally if salt-sensitive plants are to be grown. There is little danger of developing harmful levels of exchangeable sodium from the use of waters of this class.

C1-S2 Low Salinity-Medium Sodium Water: Waters of this class can be used for irrigation if the salt which accumulates, through evapotranspiration, is leached from the root-zone. This should normally occur during irrigation. If these waters are used on soils having high base exchange capacity dominated by sodium, the slow water penetration problem will be alleviated by the use of gypsum; and the salts may then be leached from the soil quite readily.

C2-S1 Medium Salinity-Low Sodium Water: Waters in this class may be used if a moderate amount of leaching occurs. Plants with moderate salt tolerance can be grown in most cases without special practices of salinity control. Very little danger exists from the development of harmful levels of exchangeable sodium, but some sodium-sensitive crops such as stone-fruit trees and avocados may accumulate injurious levels of sodium.

C2-S2 Medium Salinity-Medium Sodium Water: These waters will present a sodium hazard when used on fine-textured soils having a high base-exchange capacity. Gypsum should be applied, followed by moderate leaching. On coarse-textured or organic soils of good permeability, this water may be used without special caution.

C2-S3 Medium Salinity-High Sodium: This water, being high in sodium, will produce harmful amounts of exchangeable sodium in the soil, requiring special soil management if crops are to be produced successfully. Management practices include adequate drainage, high leaching, and organic matter additions. If the soil is not well supplied with gypsum, this amendment should be added to either the soil or the water. Chemical amendments may bring about the required condition in the soil, but their use may not be feasible for low monetary value crops.

C2-S4 Medium Salinity-Very High Sodium Water: Very high sodium waters are seldom used for irrigation except in the low and medium salinity classes. Good soil drainage is essential if waters in this class are to be used for irrigation. Waters in this class could not be used successfully except on very permeable soils or on those well supplied with calcium. If these conditions are not present, amendments may be used to supply the necessary calcium.

C3-S1 High Salinity-Low Sodium Water: This water should only be used on soils which can be leached easily. Salinity control must be practiced at all times. Only salt tolerant plants should be grown.

C3-S2 High Salinity-Medium Sodium Water: This water should be used only on those soils which have good drainage. Gypsum should be added to the soil or water, if it is not already present in the soil, to facilitate leaching. Only plants having a good salt tolerance should be grown.

C3-S3 High Salinity-High Sodium Water: This water should be used only on soils having unrestricted drainage, where special management for salinity control may be practiced. Because of the marginal nature of this water, practices should include good drainage, frequent leaching, and organic matter additions. Gypsiferous soils may not be adversely affected by the use of water of this quality, but others may develop harmful levels of exchangeable sodium. The cost of chemical amendments could be prohibitive in extreme conditions.

C3-S4 High Salinity-Very High Sodium Water: Because of the high salt content of this water, it should be used only by crops with good salt tolerance on soils having unrestricted drainage. Unfortunately, amendments may not be practical with water of very high salinity.

C4-S1 Very High Salinity-Low Sodium Water: This water is generally considered to be poor quality for irrigation, but it may be used if all other conditions are favorable. Specifically, drainage must be adequate, additional water must be applied for leaching, and only crops of the highest salt tolerance should be grown. There is little likelihood that this class of water will create an exchangeable sodium problem.

C4-S2 Very High Salinity-Medium Sodium Water: The very high salinity of this water permits occasional use and only then under favorable soil and plant conditions. An exchangeable sodium problem might develop in a soil irrigated with this water if the soil is fine-textured or otherwise poorly drained. Gypsum will reduce the sodium hazard. Only plants of high salt tolerance should be grown if water of this quality must be used.

C4-S3 Very High Salinity-High Sodium Water: Because of the excessively high salt content of this water, it is not recommended for use except under very special conditions. If used at all, the soil must be permeable and well drained. Water must be applied in considerable excess to provide for leaching, and only the most salt tolerant crops should be grown. With respect to the high sodium content, this water will contribute to the development of unfavorable conditions in the soil which in turn will require the standard treatment for the prevention and cure of high-sodium soil conditions.

C4-S4 Very High Salinity-Very High Sodium Water: This water is undesirable for irrigation with respect to both salinity and alkalinity. If used at all, it should be used very freely to leach the salt from the soil. Calcium from any source, whether dissolved from the soil or applied as an amendment, may improve the water to the point where it may have limited use.

The above classes are not rigid. Allowance must be made for soil properties and the level of management. Also, the classes do not take into account certain toxic ions which can preclude the use of water. For example, boron is essential for plant growth in minute quantities; but it is toxic to crops at relatively low concentrations. Sensitive crops, such as citrus, are often affected at levels exceeding 0.33 mg/l (23). Areas where this concentration is exceeded in a substantial number of wells are the Maricopa-Casa Grande-Coolidge area, the Tucson area, the middle reaches of the San Pedro Valley, and the Willcox-Playa area. High boron water must be used selectively on tolerant crops or mixed with better quality water.

LAND RESOURCES

Land Resource Areas

A land resource area is a geographic area characterized by a particular combination or pattern of soils, climate, water resources, land use, and types of farming. The Central Arizona Basin and Range and the Southeastern Arizona Basin and Range are the major land resource areas (MLRA's) that occur in the study area. Some minor amounts of the Southern Desert Basins, Plains, and Mountain MLRA occur in the northeastern portion of the study area. Generally, the Central Arizona Basin and Range MLRA corresponds to the Sonoran Desert section of the Basin and Range Physiographic Province and the Southeastern Arizona Basin and Range MLRA corresponds to the Mexican Highland section (Figure 7, page 2.12).

General Soil Areas

Soils of the study area have been divided into 26 soil associations. A soil association is a landscape that has a distinct proportional pattern of soils or land types. It usually consists of one or more major soils or land types and some minor soils. It is named for the major soils or land types. The soils in one association may occur in another, but in a different proportion or pattern. The 26 soil associations have been divided into six groups as shown on the General Soil Map. These groups are: (1) soils of the river bottoms and alluvial fans; (2) soils of the valley slopes; (3) shallow soils over bedrock; (4) limy soils on valley slopes and high fans; (5) soils of the mountains; and (6) eroded lands. The General Soil Map does not show the kind of soil at any particular point. It does show land patterns made up of different kinds of soils.

General information on soil characteristics, qualities, and features are given in Table 2.10. This information can be used to guide land-use planning. The factors listed in the table are amoung those that influence various uses and capabilities of the soil. Interpretations of soil properties and features significant to use for residential, industrial, recreation, and other purposes are in Table 2.11. More detailed

Table 2.10

SANTA CRUZ-SAN PEDRO RIVER BASINS
SOIL CHARACTERISTICS, QUALITIES AND FEATURES

(Information [illegible] this table is for use [illegible] general land [illegible] planning only [illegible] is [illegible] to [illegible] used for on-site planning and design.)

[illegible] [illegible]iation	Approx. Extent % Study Area	% Assoc. 1/	Depth to Bedrock or Hardpan (In.)	Permeability (In./Hr.)	Landscape Position	Parent Material	Hydrologic Soil Group	Shrink-Swell Potential	Vegetation	Elevations (Feet)	Precipitation (Inches)	Average Frost-Free Season (Days)	Major Uses
SOILS OF [illegible] RIVER BOTTOMS AND ALLUVIAL FANS													
(A1) Gilman-Antho-Pimer	11.3												
Gilman loam, 0 to 1 percent slopes		35	>60	.63-2.0	nearly level flood plains and low stream terraces	mixed alluvium	B	Low	creosote bush, mesquite, cacti, annual grasses	1000 to 2600	7 to 10	250 to 300	limited grazing, irrigated cropping
Antho sandy loam, 0 to [illegible] percent slopes		35	>72	2.0-6.3	nearly level flood plains and gently sloping alluvial fans	mixed alluvium	[illegible]	Low	creosote bush, mesquite, cacti, annual grasses	1000 to 2600	7 to 10	250 to 300	limited grazing, irrigated cropping
Pimer clay loam, 0 to 1 percent slopes		20	>60	.20-.63	nearly level to gently sloping flood plains and low terraces	mixed alluvium	[illegible]	Moderate	mesquite, creosote bush, grasses	1000 to 3000	7 to 10	250 to 300	limited grazing, irrigated cropping
(A2) Comoro-Anthony-Grabe	2.8												
Comoro sandy loam, [illegible] to [illegible] percent slopes		55	>60	2.0-6.3	nearly level to gently sloping flood plains and low terraces	mixed alluvium	B	Low	catclaw, mesquite, grasses	2200 to [illegible]	9 to 16	160 to 265	grazing, irrigated cropping
Anthony sandy loam [illegible] to 3 percent slopes		25	>60	2.0-6.3	flood plains, fans and low terraces	mixed alluvium	[illegible]	Low	catclaw, mesquite, grasses	2200 to 4500	9 to 12	180 to 275	grazing, irrigated cropping
Grabe loam, [illegible] to 3 percent slopes		20	>40	.63-2.0	nearly level to gently sloping flood plains, terrace and fans	mixed alluvium	B	Moderate	mesquite, catclaw, grasses	2200 to 5000	9 to 18	160 to 240	grazing, irrigated cropping
(A3) Guest	0.7												
Guest clay, 0 to 1 percent slopes		90	>60	.06-0.2	flood plains, alluvial fans, old terraces	mixed alluvium	[illegible]	High	grasses, mesquite	2200 to 3200	9 to 20	200 to 275	grazing, irrigated cropping
(A4) Gothard-Crot-Stewart	1.3												
Gothard loam, 0 to 1 percent slopes		40	>60	<.06	alkali flats bordering playas	mixed alluvium	D	High	alkali sacaton, salt grasses	3800 to 4300	10 [illegible] 12	155 to 220	grazing, irrigated cropping
Crot loam, 0 to 1 percent slopes		25	>60	<.06	alkali flats bordering playas	mixed alluvium	D	High	alkali sacaton, salt grasses	[illegible] to 4300	10 to 12	155 to 220	grazing, irrigated cropping
Stewart loam, 0 to 1 percent slopes		15	4 to 20	<.06	low terraces and alkali flats bordering playas	mixed alluvium	D	Low	alkali sacaton, salt grasses	3800 to 4300	10 to 12	155 to 220	grazing (50 percent barren), limited irrigated cropping
SOILS OF THE VALLEY SLOPES													
(B1) Mohall-Casa Grande-Antho	8.4												
Mohall loam, 0 to [illegible] percent slopes		50	>60	.20-.63	fans and valley slopes	mixed alluvium	[illegible]	Moderate	creosote bush, mesquite, annual grasses	1000 to 3000	7 to 10	250 to 300	limited grazing, irrigated cropping
Casa Grande clay loam, [illegible] to [illegible] percent slopes		20	>60	.06-.20	generally concave alluvial fans and plains	mixed alluvium	C	Moderate	creosote bush, chamiza, mesquite	1000 to 2000	7 to 10	240 to 300	limited grazing, irrigated cropping
Antho sandy loam, 0 to 2 percent slopes		20	>60	2.0-6.3	flood plains, fans, and low terraces	mixed alluvium	[illegible]	Low	creosote bush, cacti, palo verde, iron wood, annual grasses	1000 to 3000	7 to 10	250 to 300	limited grazing, irrigated cropping
(B2) Mohave-Pinaleno-Latene	4.7												
Mohave loam, 1 to 5 percent slopes		40	>60	.20-.63	fans and valley slopes	mixed alluvium	[illegible]	Moderate	mesquite, creosote bush, palo verde, grasses	2200 to 5000	10 to 12	[illegible]0 to 275	grazing, irrigated cropping
Pinaleno very gravelly sandy loam, 0 to 5 percent slopes		35	>60	.20-.63	fans and terraces	stratified, mixed very gravelly alluvium	[illegible]	Moderate	creosote bush, cacti, mesquite	2200 to 4000	10 to 11	200 to 275	grazing
Latene loam, [illegible] to 3 percent slopes		15	>60	.63-2.0	fans and terraces	mixed alluvium	[illegible]	Low	creosote bush, desert sage, cacti, grasses	2200 to 4800	10 to 11	220 to 275	grazing, irrigated cropping
(B3) Casa Grande-La Palma	1.4												
Casa Grande loam, 0 to 2 percent slopes		60	>60	.06-.20	generally concave valley plains	mixed alluvium	C	Moderate	mesquite, creosote bush, cacti, annual grasses	1000 to 2000	7 to 11	260 to 300	limited grazing, irrigated cropping
La Palma loam, 0 to [illegible] percent slopes		20	20-60	.06-20	stream terraces, valley plains and fans	mixed alluvium	C	Moderate	chamiza, creosote bush, mesquite	1000 to 2000	7 to 10	250 to 300	limited grazing, irrigated cropping
(B4) Mohall-Vecont	1.4												
Mohall sandy loam, 0 to 2 percent slopes		55	>60	.20-.63	upper part of fans	mixed alluvium	[illegible]	Moderate	creosote bush, mesquite, palo verde, annual grasses	1000 to 3000	7 to 10	250 to 300	limited grazing, irrigated cropping
Vecont clay, [illegible] to 1 percent slopes		30	>60	.06-.20	lower part of fans	mixed alluvium	D	High	grasses, desert saltbush, mesquite, creosote bush, cacti	1000 to 2600	7 to 10	260 to 300	limited grazing, irrigated cropping
(B5) White House-Bernardino	4.6												
White House gravelly loam, 2 to 8 percent slopes		55	>60	.06-.20	plains and alluvial fans	mixed alluvium	C	High	catclaw, white-thorn, oak, grasses	3300 to 5400	12 to 18	164 to 250	grazing, irrigated cropping
[illegible]nardino gravelly loam, 2 to [illegible] percent slopes		30	>60	.06-.20	dissected alluvial fans	mixed alluvium	[illegible]	Moderate - top foot. Low - below top foot	grasses, oak, juniper	3500 to 5500	12 to 16	200 to 250	grazing
(B6) Caralampi-White House	6.2												
Caralampi gravelly sandy loam, 10 to 30 percent slopes		65	>60	.20-.63	dissected alluvium fans	mixed alluvium	[illegible]	Low	grasses, mesquite, catclaw, mimosa	3000 to 5000	14 to 16	200 to 260	grazing, home sites, wildlife
White House gravelly loam, 5 to 10 percent slopes		20	>60	.06-.20	old alluvial fans	mixed alluvium	C	High	calliandra, mesquite, Apache plume, grasses	3300 to 5400	12 to 18	164 to 250	grazing, irrigated cropping
(B7) Caralampi	3.8												
Caralampi gravelly sandy loam, 30 to 60 percent slopes		80	>60	.20-.63	dissected alluvial fans	mixed alluvium	[illegible]	Low	catclaw, mesquite, mimosa, calliandra, grasses	3000 to 5000	14 to 16	200 to 260	grazing, wildlife habitat
(B9) Bonita-Sontag	1.4												
Bonita gravelly silty clay, 0 to [illegible] percent slopes		65	>60	<.06	valley plains	basalt, volcanic cinders and ash	[illegible]	High	grasses, mesquite	[illegible] to 5000	14 to 20	160 to 210	grazing
Sontag Cobbly clay loam 0 [illegible] 25 percent slopes		20	>60	<.06	plains and colluvial slopes	volcanic cinders and ash	[illegible]	High	grasses, mesquite	4300 to 5300	12 to 15	160 to 200	grazing
(B10) Continental-Tubac	10.4												
Continental gravelly sandy loam, 2 to 30 percent slopes		60	>60	.06-.20	fans and valley slopes	loamy alluvium	C	High	grasses, acacia, mesquite	2000 to 4500	10 to 14	170 to 275	grazing, irrigated cropping
Tubac gravelly sandy loam, 0 to 5 percent slopes		30	>60	.60-.20	fans and valley slopes	gravelly alluvium	C	High	mesquite, Lycium, grasses	2000 to 4500	10 to 14	170 to 275	grazing, irrigated cropping
(B11) Casto-Martinez 2/	.6												
Casto very gravelly sandy loam, 10 to [illegible] percent slopes		60	>60	.06-.20	alluvial fans	gravelly alluvium	C	Moderate Low in Substrata	oak, juniper, grasses	5000 to 6500	16 to 22	140 to 200	grazing, wildlife habitat
Martinez gravelly loam, [illegible] to 3 percent slopes		20	>60	<.06	fans	mixed alluvium	D	High	grasses manzanita, oak	5000 to 5800	15 to 22	140 to 200	grazing, wildlife habitat
SHALLOW UPLAND SOILS [illegible]													
(C1) Cellar-Graham-Cherioni	4.0												
Cellar very gravelly loam, 5 [illegible] 30 percent slopes		50	4 to 20	.63-2.0	hills	granite	D	Low	catclaw, mesquite, creosote bush, grasses	1500 to [illegible]	10 to 12	[illegible] to 270	grazing, wildlife habitat
Graham cobbly clay loam, [illegible] to 30 percent slopes		20	[illegible] [illegible] 20	.06-.20	hills and mountains	basalt	D	High	oak, juniper, creosote bush, ocotillo, grasses	[illegible] to 5500	10 to 18	[illegible] to 260	grazing, wildlife habitat
Cherioni gravelly very fine sandy loam, 0 to 15 percent slopes		20	5 to [illegible]	.63-2.0	ridges, hills and mountains	andesite, rhyolite, dacite, or granite	D	Low	palo verde, catclaw, mimosa, creosote bush, grasses, cacti	1500 to 2000	[illegible] to 10	250 to 300	grazing, wildlife habitat

Table 2.10 (Continued)

SANTA CRUZ-SAN [redacted] RIVER [redacted]
SOIL CHARACTERISTICS, QUALITIES [redacted]

(Information in this table is for [redacted] in general land [redacted] planning only and is not to be used for on-site planning and design.)

Soil Association	Approx. Extent % Study Area	% Assoc. 1/	Depth to Bedrock or Hardpan (In.)	Permeability (In./Hr.)	Landscape Position	Parent Material	Hydrologic Soil Group	Shrink-Swell Potential	Vegetation	Elevations (Feet)	Precipitation (Inches)	Average Frost-Free Season (Days)	Major Uses
LIMY SOILS ON VALLEY SLOPES AND HIGH FANS													
(D1) Rillino-Cave	.4												
Rillino gravelly sandy loam, 2 to 15 percent slopes		30	>60	2.0-6.3	fans and terraces	mixed gravelly alluvium	B	Low	creosote bush, mesquite, cacti, grasses	[redacted] to [redacted]	7 to 10	250 to 300	limited grazing, irrigated cropping
Cave gravelly sandy loam, 2 to 15 percent slopes		50	4 to 20	.63-2.0	old alluvial fans and terraces	gravelly or cobbly valley fill of mixed sources	D	Low	creosote bush, mesquite, cacti, grasses	[redacted] 2500	7 to 10	250 to 300	limited grazing
(D2) Laveen-Rillito	1.5												
Laveen loam, 0 to 3 percent slopes		50	>60	.63-2.0	fans and terraces	mixed alluvium	B	Low	mesquite, creosote bush, cacti, palo verde annual grasses	1000 to 250	7 to 10	250 to 00	limited grazing, irrigated cropping
Rillito gravelly sandy loam, 0 to 30 percent slopes		30	>60	2.0-6.3	fans and terraces	mixed gravelly alluvium	B	Low	creosote, desert sage, cacti, annual grasses	[redacted] to 2500	7 to 10	250 to 300	limited grazing irrigated cropping
(D3) Kimbrough-Cave	2.9												
Kimbrough gravelly loam, 0 to 25 percent slopes		50	4 to 20	.63-2.0	plains	mixed alluvium	D	Low	grasses, yucca	3000 to 5000	10 to 17	180 to 250	grazing, wildlife habitat
Cave gravelly sandy loam, 0 to 25 percent slopes		30	4 to 20	.63-2.0	foot slopes of hills	gravelly or cobbly valley fill of mixed sources	B	Low	creosote, white-thorn, grasses	2000 to [redacted]	10 to 12	180 to 270	grazing, wildlife habitat
(D4) Hathaway-Nickel	3.6												
Hathaway gravelly loam, 0 to 30 percent slopes		45	>60	.63-2.0	dissected alluvial fans and plains	gravelly alluvium	B	Low	grasses, mesquite, creosote bush	3000 to 5400	12 to 18	190 to 270	grazing, wildlife habitat
Nickel gravelly sandy loam, 10 to 30 percent slopes		40	>60	.20-.63	dissected terraces	very gravelly alluvium	B	Low	mesquite, creosote bush, grasses	2500 to [redacted]	10 to 14	200 to 270	grazing, wildlife habitat
(D5) Elfrida-Karro	0.9												
Elfrida silty clay loam, 0 to 1 percent slopes		45	>60	.20-.63	valley plains	mixed alluvium	B	Moderate	grasses, mesquite, creosote bush	[redacted] to 4400	10 to 14	155 to 220	grazing, irrigated cropping
Karro loam, 0 to 15 percent slopes		45	>60	.20-.63	valley plains	mixed alluvium	B	Moderate	mesquite, creosote bush, grasses	3600 to 4800	10 to 12	180 to 225	grazing irrigated cropping
SOILS OF THE MOUNTAINS													
(E1) Rock outcrop-Cherioni-Gachado	4.5												
Rock outcrop, 15 to 75 percent slopes		50	--	--	mountains	volcanic and granitic rock	D	Low	---	1100 to 5500	7 to 16	180 to 300	---
Cherioni gravelly very fine sandy loam, 5 to 60 percent slopes		20	5 to 20	.63-2.0	ridges, hills and mountains	andesite, rhyolite, dacite, or granite	D	Low	creosote bush, palo verde, mimosa, catclaw, cacti, grasses	1500 to [redacted]	7 to 10	250 to 300	grazing, wildlife habitat
Gachado very cobbly loam, 5 to 20 percent slopes		15	[illegible] to 20	.06-.20	toe slopes of hills and mountains	latite, andesite, rhyolite, basalt and tuff	D	Moderate	creosote bush bursage, cacti, palo verde	1100 to 2000	7 to 10	250 to 300	wildlife habitat, limited grazing
(E2) Lampshire-Graham-Rock outcrop	8.6												
Lampshire very cobbly loam, 5 to 70 percent slopes		25	4 to 20	.63-2.0	mountains and ridges	andesite, rhyolite, dacite or granite	D	Low	oak, pinon juniper, cacti, grasses	2500 to 5500	10 to 18	180 to 280	limited grazing wildlife habitat
Graham cobbly clay loam, 5 to 25 percent slopes		20	[illegible] to 20	.06-.20	mountains	basalt	D	High	ironwood, mesquite, palo verde, grasses	3000 to 5500	10 to 18	180 to 260	limited grazing, wildlife habitat
Rock outcrop, 15 to 75 percent slopes		40	—	—	mountains	volcanic and granite rock	D	Low	---	2500 to 5500	10 to 18	180 to 280	---
(E3) Mirabal-Barkerville-Rock outcrop	0.6												
Mirabal stony loam, 5 to 70 percent slopes		30	20 to 35	.63-2.0	mountains	granite and gniess	C	Moderate	conifers, oak brush, grasses	[redacted] to [redacted]	20 to 30	100 to 180	recreation, timber, wildlife habitat
Barkerville gravelly sandy loam, 5 to 60 percent slopes		20	20 to 40	.60-2.0	mountains	granite	C	Low	oak, juniper, manzanita, pine, grasses	4000 to 7500	15 to 20	170 to 240	grazing, recreation, wildlife habitat
Rock outcrop, 15 to 75 percent slopes		35	—	—	mountains	gniess	D	Low	---	[redacted] to 9200	20 to 30	110 to 180	---
(E4) Faraway-Barkerville-Rock outcrop	9.5												
Faraway very gravelly loam, 10 to 75 percent slopes		25	5 to 20	.60-2.0	mountains	andesite, rhyolite or granite	D	Low	oak, juniper, pine, grasses	[redacted] to 7500	14 to 20	170 to 240	grazing, recreation, wildlife habitat
Barkerville gravelly sandy loam, 5 to 60 percent slopes		25	20 to 40	.60-2.0	mountains	granite	C	Low	oak, juniper, manzanita, pine, grasses	4000 to 7500	15 to 20	170 to 240	grazing, recreation, wildlife habitat
Rock outcrop, 15 to 75 percent slopes		40	--	--	mountains	andesite, rhyolite or granite	D	Low	---	3000 to 7500	15 to 20	170 to 240	---
(E5) Tortugas-Rock outcrop	2.7												
Tortugas cobbly loam, 2 to 70 percent slopes		45	6 to 20	.60-2.0	mountains	limestone	D	Low	cliffrose, juniper, oak, grasses	4000 to 8400	10 to 25	120 to 200	grazing, recreation, wildlife habitat
Rock outcrop, 15 to 75 percent slopes		40	<4	<.06	mountains	limestone	D	Low	---	4000 to 8100	10 to 25	120 to 200	---
ERODED LANDS													
(F1) Eroded and gullied Calciorthids, 15 to 60 percent slopes	2.0	90	variable	variable	dissected escarpments	variable	C	Low to High	mesquite, cacti, creosote bush, grasses	2500 to 4500	10 to 18	180 to 270	grazing, wildlife habitat

1/ These percentages do not necessarily add up to 100 because of inclusions within mapping unit delineations of similar or dissimilar soils.

2/ Approximately 10 percent of this unit is somewhat poorly drained Canelo soils.

Table 2.11

SANTA CRUZ-SAN PEDRO RIVER BASINS
SOIL INTERPRETATIONS

(Information in this table is for use in general land use planning only and is not for use in on-site planning and design)

Soil Association	Septic Tank Absorption Fields	Dwellings Without Basements	Sanitary Land Fill (Trench Type)	Sewage Lagoons	Camp Areas	Playgrounds	Paths and Trails	Picnic Areas	Suitability as Source of Road Fill	Land Classification 1/
	DEGREE AND KIND OF LIMITATIONS FOR--									
SOILS OF THE RIVER BOTTOMS [redacted] ALLUVIAL FANS										
(A1) Gilman-Antho-Pimer										
Gilman loam, 0 to 1 percent slopes	Slight - Severe-where flooded	Slight - Severe-where flooded	Slight - Severe-where flooded	Moderate - Seepage. Severe-where flooded	Slight - possible dust problem - Severe where flooded	Slight - possible dust problem	Slight - possible dust problem	Slight - possible dust problem	Fair - ML material	1
Antho sandy loam, 0 to 1 percent slopes	Slight - Severe-where flooded	Slight - Severe-where flooded	Slight - Severe-where leaching will contaminate ground water	Severe - seepage.	Slight - possible dust problem Severe-where flooded	Slight - possible dust problem	Slight - Possible dust problem	Slight - possible dust problem	Good - SM material	2
Pimer clay loam, 0 to 1 percent slopes	Severe - Moderately slow permeability	Moderate - Moderate shrink-swell. Severe where flooded	Moderate - Moderately fine-textured Severe where flooded	Slight - Severe-where flooded	Moderate - Moderately slow permeability	Moderate-Moderately slow permeability; moderately fine texture	Moderate - Moderately fine texture	Moderate - Moderately fine texture	Fair - ML or CL material	1
(A2) Comoro-Anthony-Grabe										
Comoro sandy loam, 0 to 3 percent slopes	Slight - Severe-where flooded	Slight - Severe-where flooded	Severe - moderately rapid permeability	Severe-Seepage; some areas subject to flooding	Slight - Severe where flooded	Slight - possible dust problem	Slight - possible dust problem	Slight - possible dust problem	Good - SM material	1
Anthony sandy loam, 0 to 1 percent slopes	Slight - Severe-where flooded	Slight - Severe-where flooded	Severe - moderately rapid permeability	Severe-Seepage; [redacted] areas subject to flooding	Slight - Severe-where flooded	Slight - possible dust probl[redacted]	Slight - possible dust problem	Slight - possible dust problem	Good - SM material	2
Grabe loam, 0 to 3 percent slopes	Moderate-Moderate permeability. Severe-where flooded	Slight - Severe-where flooded	Slight - Severe-where flooded	Moderate - Seepage. Severe-where flooded	Slight - Severe-where flooded	Slight - possible dust problem	Slight	Slight - possible dust problem	Fair - ML material	1
(A3) Guest										
Guest clay, 0 to 1 percent slopes	Severe - slow permeability	Severe - high shrink-swell	Severe - clayey textures	Slight	Severe - clay surface. Frequent flooding in places	Severe - clay surface	Moderate-dusty	Moderate-dusty	Poor - CH material	2
* (A4) Gothard-Crot-Stewart										
Gothard loam, 0 to 1 percent slopes	Severe - very slow permeability	Severe - high shrink-swell	Moderate - restricted drainage	Slight - Severe-where flooded	Severe - very slow permeability	Severe - very slow permeability	Moderate-dusty	Moderate-dusty	Poor - CH material	4
Crot loam, 0 to 1 percent slopes	Severe-very slow permeability	Severe-frequent flooding, high shrink-swell	Severe - frequent flooding	Severe-frequent flooding	Severe-very slow permeability; frequent flooding	Severe - very slow permeability	Moderate-dusty	Moderate-dusty	Fair - stratified with CH material	4
Stewart loam, 0 to 1 percent slopes	Severe-shallow to cemented hardpan	Severe-shallow to hardpan	Moderate - rare flooding	Severe-shallow to cemented hardpan	Severe-very slow permeability	Severe-very slow permeability	Moderate-dusty	Moderate-dusty	Poor-shallow to hardpan	4
SOILS OF THE VALLEY SLOPES										
(B1) Mohall-Casa Grande-Antho										
Mohall loam, 0 to 2 percent slopes	Severe-moderately slow permeability, unless tile placed below clay loam	Moderate-moderate shrink-swell Severe-where flooded	Slight to Moderate - loam and clay loam subsoil. Severe - where flooded	Slight	Moderate - Moderately slow permeability	Moderate - Moderately slow permeability	Slight - possible dust problem	Slight - possible dust problem	Poor - CL material	1
Casa Grande clay loam, 0 to 2 percent slopes	Severe-slow permeability	Moderate-moderate shrink-swell	Moderate - clay loam subsoil	Slight	Moderate - slow permeability; possible dust	Moderate - slow permeability; possible dust	Slight - possible dust problem	Slight - possible dust problem	Fair to Poor - ML to CL material	2
Antho sandy loam, 0 to 2 percent slopes	Slight - Severe where flooded	Slight - Severe where flooded	Slight - Severe-where flooded or where leaching will contaminate ground water	Severe - seepage	Slight - Severe-where flooded	Slight - Possible dust problem	Slight	Slight	Good - SM material	2
(B2) Mohave-Pinaleno-Latene										
Mohave loam, 1 to 5 percent slopes	Severe-moderately slow permeability unless tile placed below clay loam	Moderate-moderate shrink-swell	Moderate-clay loam subsoil.	Slight	Moderate - moderately slow permeability	Moderate - moderately slow permeability	Slight - possible dust problem	Slight - possible dust problem	Fair - CL to SM material	2
Pinaleno very gravelly sandy loam, 0 to 5 percent slopes	Severe-moderately slow permeability, unless tile placed below clay loam	Slight	Moderate-high content of gravel	Severe - seepage	Severe-very gravelly surface	Severe-very gravelly surface	Severe-very [illegible]	Severe-very [illegible]	Good - GC or GM [illegible]	3

Table 2.11 (Continued)

Soil Association	DEGREE AND KIND OF LIMITATIONS FOR-- Septic Tanks Absorption Fields	Dwellings Without Basements	Sanitary Land Fill (Trench Type)	Sewage Lagoons	Camp Areas	Playgrounds	Paths and Trails	Picnic Areas	Suitability [illegible] Source of Road Fill	[illegible] 1/ Classification
(B3) Casa Grande-La Palma										
Casa Grande loam, 0 to 3 percent slopes	Severe - slow permeability	Moderate-moderate shrink-swell	Moderate-clay loam subsoils	Slight	Moderate-slow permeability; possible dust	Moderate-slow permeability; possible dust	Slight-possible dust problem	Slight-possible dust probl[illegible]	Poor-ML or CL material	2
La Palma loam, 0 to 2 percent slopes	Severe - slow permeability and hardpan	Moderate-moderate shrink-swell	Severe - hardpan	Slight - if constructed on surface. Severe-if excavated	Moderate-slow permeability; possible dust	Moderate-sl[illegible] permeability; possible dust	Slight-possible dust problem	Slight-possible dust problem	Poor-ML or CL material	3
(B4) Mohall-Vecont										
Mohall sandy loam, 0 to 2 percent slopes	Severe-moderately slow permeability unless tile placed below clay loam	Moderate-moderate shrink-swell. Severe - where flooded.	Slight to moderate-loam and clay loam subsoil. Severe-where flooded.	Moderate-seepage Severe-where flooded.	Moderate - moderately slow permeability	Slight	Slight	Slight	Poor-CL material	1
Vecont clay, 0 to 1 percent slopes	Severe-slow permeability	Severe-high shrink-swell; possible flooding	Severe-clay	Slight - Severe-where flooded	Severe-clay; possible flooding	Severe-clay; possible flooding	Severe-clay	Severe-clay; possible flooding	Poor-CH Material	2
(B5) White House-Bernardino										
White House gravelly loam, 2 to 8 percent slopes	Severe-slow permeability	Severe-high shrink-swell	Severe-clay texture	Moderate - 2 to 5 percent slopes; seepage	Moderate-slow permeability	Moderate-slow permeability; surface gravelly	Moderate-surface gravelly	Moderate-surface gravelly	Poor-CH material	3
Bernardino gravelly clay loam, 2 to 8 percent slopes	Slight	Slight	Slight	Moderate- 2 percent slopes. Severe-if excavated below one foot	Moderate - gravelly	Moderate-gravelly; slopes 2 to 6 percent. Severe - slopes >6 percent	Moderate-gravelly	Moderate-gravelly	Fair-top foot CH material	3
(B6) Caralampi-White House										
Caralampi gravelly sandy loam, 10 to 30 percent slopes	Moderate-slopes 10 to 15 percent. Severe-slopes more than 15 percent	Moderate-slopes 10 to 15 percent. Severe-slopes [illegible] than 15 percent	Moderate-slope; gravelly; porous in lower profile	Severe-slopes exceed 1 percent; Very gravelly	Moderate-gravelly and cobbly. Severe-where slopes >15 percent	Severe-gravelly and cobbly; slopes over 6 percent	Moderate-gravelly and cobbly. Severe-where slopes exceed 25 percent	Moderate-gravelly and cobbly. Severe-where slopes over 15 percent	Good-SM or GC material	6
White House gravelly loam, 5 to 10 percent slopes	Severe-slow permeability	Severe-high shrink-swell	Severe-clay textures	Moderate-on slopes to 7 percent. Severe-slopes over 7 percent	Moderate - gravelly surface; slow permeability	Severe-gravelly surface. Slow permeability. Some slopes over 6 percent	Moderate-gravelly	Moderate-gravelly	Poor-CH material	6
(B7) Caralampi										
Caralampi gravelly sandy loam, 30 to 60 percent slopes	Severe-slopes >15 percent	Severe-slopes >15 percent	Severe-slopes >15 percent	Severe-slopes over 7 percent; Porous substrata	Severe-slopes >15 percent	Severe-slopes >6 percent	Severe-slopes >25 percent	Severe-slopes >15 percent	Good-SM or GC material	6
(B9) Bonita-Sontag										
Bonita gravelly silty clay, 0 to 8 percent slopes	Severe-very slow permeability	Severe-high shrink-swell	Severe-clay textures	Moderate-gravelly	Severe-clay texture; very slow permeability	Severe-gravelly clay texture; very slow permeability	Severe-gravelly clay	Severe-clay textures; very slow permeability	Poor CH material	6
Sontag cobbly clay loam, 0 to 25 percent slopes	Severe-very slow permeability	Severe-high shrink-swell	Severe-clay textures	Moderate-cobbly slopes 2 to 7 percent. Severe-slopes over 7 percent	Severe-clay textures; very slow permeability	Severe-gravelly clay texture; very slow permeability	Severe-gravelly clay	Severe-clay texture; very slow permeability	Poor-CH material	6
(B10) Continental-Tubac										
Continental gravelly sandy loam, 2 to 30 percent slopes	Severe-slow permeability	Severe-high shrink-swell	Moderate-clay texture	Moderate-slopes under 7 percent. Severe-slopes	Moderate-gravelly; slopes under 15 percent. Severe-slopes over 15 percent	Severe-gravelly	Moderate-gravelly	Moderate-gravelly. Severe-slopes 15 percent	Good-in substrata	3
Tubac gravelly sandy loam, 0 to 5 percent slopes	Severe-slow permeability	Severe-high shrink-swell	Severe-clay texture	Slight-slopes under 2 percent. Moderate-slopes [illegible] to [illegible] percent	Moderate-gravelly	Severe-gravelly	Moderate-gravelly	Moderate-gravelly	Poor-CH material	3
(B11) Casto-Martinez										
Casto very gravelly sandy loam, 10 to 40 percent slopes	Moderate-slopes 10 to 15 percent, Severe-slopes over 15 percent	Moderate-slopes 10 to 15 percent. Severe-slopes over 15 percent	Slight-0 to 15 percent slopes. Moderate-15 to 25 percent slopes. Severe-over 25 percent slopes	Severe-slopes over 10 percent; very gravelly	Severe-very gravelly; [illegible] steep slopes	Severe-very gravelly	Severe-very gravelly; some steep slopes	Severe-very gravelly; [illegible] steep slopes	Good-slopes under 15 percent. Fair-slopes 15 to 25 percent. Poor-slopes over 25 percent	6
Martinez gravelly loam, 0 to 3 percent slopes	Severe-very slow permeability	Severe-high shrink-swell	Severe-clay texture	Slight	Severe-clay texture	Severe-clay texture	Severe-clay texture	Severe-clay texture	Poor-CH material	3

Table 2.11 (Continued)

Soil Association	Septic Tanks Absorption Fields	Dwellings Without Basements	Sanitary Land Fill (Trench Type)	Sewage Lagoons	Camp Areas	Playgrounds	Paths and Trails	Picnic Areas	Suitability [redacted] Source of Road Fill	Land Classification 1/
	DEGREE [redacted] KIND OF LIMITATIONS FOR--									
SHALLOW [redacted] SOILS [redacted] [redacted]										
(C1) Cellar-Graham-Cherioni										
Cellar very gravelly loam, 5 to 30 percent slopes	Severe-shallow to bedrock; [redacted] slopes over 15 percent	Severe-shallow to bedrock; [redacted] slopes over 15 percent	Severe-shallow to bedrock	Severe-shallow to bedrock	Severe-very gravelly; [redacted] slopes over 15 percent	Severe-slopes over 6 percent; very gravelly	Severe-rock and very gravelly	Severe-rocky [redacted] very gravelly; [redacted] slopes over 15 percent	Poor-limited depth	6
Graham cobbly clay loam, 5 to 30 percent slopes	Severe-shallow to bedrock; some slopes over 15 percent	Severe-shallow to bedrock; [redacted] slopes [redacted] 15 percent; high shrink-swell	Severe-shallow to bedrock	Severe-shallow to bedrock	Severe-clay texture. Some slopes over 15 percent	Severe-clay texture; cobbles	Severe-clay texture; cobbles	Severe-clay texture; cobbles; [redacted] slopes over 15 percent	Poor-CH material limited depth	6
Cherioni gravelly very fine sandy loam, 0 to	Severe-shallow to bedrock	Severe-shallow to bedrock	Severe-shallow to bedrock	Severe-shallow to bedrock	Severe-very gravelly and cobbly	Severe-very gravelly and cobbly	Severe-very gravelly and cobbly	Severe-very gravelly [redacted] cobbly	Poor-limited depth	6
LIMY SOILS ON VALLEY [redacted] AND HIGH FANS										
(D1) Billino-Cave										
Billino gravelly sandy loam, 2 to 15 percent slopes	Slight- <8 percent slopes; Moderate-8 to 15 percent slopes; Severe- >15 percent slopes	Slight- <8 percent slopes; Moderate-8 to 15 percent slopes; Severe- >15 percent slopes	Slight-possible dust problem; Moderate-15 to 25 percent slopes; Severe- >25 percent slopes	Moderate-2 - [redacted] percent slopes; seepage. Severe- >7 percent slopes	Moderate-where gravelly; Severe- >15 percent slopes	Severe-gravelly	Moderate-gravelly	Moderate-gravelly Severe- >15 percent slopes	Good	2
Cave gravelly sandy loam, 2 to 15 percent slopes	Severe-shallow to hardpan	Severe-shallow to hardpan	Severe-shallow to hardpan	Severe-shallow to hardpan	Moderate-gravelly; slow permeability	Severe-gravelly	Moderate-gravelly	Moderate-gravelly	Fair-limited depth	6
(D2) Laveen-Billito										
Laveen loam, 0 to 3 percent slopes	Slight	Moderate-ML materials	Slight-possible dust problem	Moderate-seepage	Slight-possible dust problem	Slight-possible dust problem	Slight-possible dust problem	Slight-possible dust problem	Fair-ML material	2
Billito gravelly sandy loam, 0 to 30 percent slopes	Slight- [redacted] percent slopes. Moderate-8 to 15 percent slopes. Severe- >15 percent slopes.	Slight- 8 percent slopes. Moderate-8 to 15 percent slopes. Severe- >15 percent slopes	Slight-possible dust problem; Moderate-15 to 25 percent slopes; Severe- >25 percent slopes	Moderate-2 - 7 percent slopes; seepage. Severe- >7 percent slopes	Moderate-gravelly. Severe- >15 percent slopes	Severe-gravelly	Moderate gravelly	Moderate-gravelly. Severe- >15 percent slopes	Good	2
(D3) Kimbrough-Cave										
Kimbrough gravelly loam, 0 to 25 percent slopes	Severe-shallow to hardpan	Severe-shallow to hardpan	Severe-shallow to hardpan	Severe-shallow to hardpan	Moderate-gravelly; slopes up to 15 percent. Severe-slopes >15 percent	Severe-gravelly	Moderate-gravelly	Moderate-gravelly. Severe-slopes >15 percent	Good	6
Cave gravelly sandy loam, 0 to 25 percent slopes	Severe-shallow to hardpan	Severe-shallow to hardpan	Severe-shallow to hardpan	Severe-shallow to hardpan	Moderate-gravelly. Severe-slopes >15 percent	Severe-gravelly	Moderate-gravelly	Moderate-gravelly. Severe-slopes >15 percent	Fair-limited depth	6
(D4) Hathaway-Mickel										
Hathaway gravelly loam, 0 to 30 percent slopes	Moderate-Moderate permeability. Severe-slopes >15 percent	Slight-slopes <[redacted] percent. Moderate-slopes [redacted] to 15 percent. Severe-slopes >15 percent	Moderate-loamy sand textures. Severe-slopes >25 percent	Moderate-seepage Severe-slopes >7 percent	Moderate-gravelly. Severe-slopes >15 percent	Severe-gravelly	Moderate-gravelly	Moderate-gravelly. Severe-slopes >15 percent	Good	6
Mickel gravelly sandy loam, 10 to 30 percent slopes	Severe-slopes >15 percent; moderately slow permeability	Moderate-slopes <15 percent. Severe-slopes >15 percent	Moderate-loamy sand textures. Severe-slopes >25 percent	Slight - Severe-where excavated; slopes >7 percent	Moderate-gravelly. Severe-slopes >15 percent	Severe-gravelly	Moderate-gravelly	Moderate-gravelly. Severe-slopes >15 percent	Good	6
(D5) Elfrida-Karro										
Elfrida silty clay loam 0 to [redacted] percent slopes	Severe-moderately slow permeability	Moderate-moderate shrink-swell	Moderate-silty clay loam	Slight	Moderate-dust problem	Moderate-moderately slow permeability; dust problem	Moderate-dust problem	Moderate-dust problem	Poor-CL material	1
Karro loam, 0 to 15 percent slopes	Severe-moderately slow permeability	Moderate-moderate shrink-swell	Slight	Slight-slopes under 2 percent. Moderate-slopes 2 to 7 percent. Severe-slopes >7 percent	Moderate - Moderately slow permeability	Moderate-moderately slow permeability Severe-slopes >6 percent	Slight	Slight- <8 percent slopes. Moderate-8 to 15 percent slopes	Poor-CH material	1 - 0.3 percent slopes 6 - 3 percent slopes

Table 2.11 (Continued)

SANTA CRUZ-SAN PEDRO RIVER [redacted]
SOIL INTERPRETATIONS

Soil Association	Septic Tanks Absorption Fields	Dwellings Without Basements	Sanitary Land Fill (Trench Type)	Sewage Lagoons	Camp Areas	Playgrounds	Paths and Trails	Picnic Areas	Suitability as Source of Road Fill	Land Classification 1/
	DEGREE [redacted] KIND OF LIMITATIONS FOR--									
SOILS OF THE MOUNTAINS										
(E1) Rock Outcrop-Cherioni-Cachado										
Rock Outcrop, 15 to 75 percent slopes	Severe-bedrock	Severe-bedrock; slopes up to 75 percent	Severe-bedrock	Severe-bedrock	Severe-bedrock	Severe-bedrock	Severe-rock outcrop	Severe-bedrock	Poor-rock	6
Cherioni gravelly very fine sandy loam, 5 to 60 percent slopes	Severe-shallow to bedrock	Severe-shallow to bedrock	Severe-shallow to bedrock	Severe-shallow to bedrock	Severe-very gravelly and cobbly	Severe-very gravelly and cobbly	Severe-very gravelly and cobbly	Severe-very gravelly and cobbly	Poor-limited depth	6
Cachado very cobbly loam, 5 to 20 percent slopes	Severe-shallow to bedrock; slow permeability	Severe-shallow to bedrock; slopes >15 percent	Severe-shallow to bedrock	Severe-shallow to bedrock	Severe-slopes >15 percent; very cobbly	Severe-very cobbly	Severe-very cobbly	Severe-slopes >15 percent; very cobbly	Poor-CL material; limited depth	6
(E2) Lampshire-Graham-Rock Outcrop										
Lampshire very cobbly loam, 5 to 70 percent slopes	Severe-shallow to bedrock	Severe-shallow to bedrock; slopes >15 percent	Severe-shallow to bedrock	Severe-shallow to bedrock	Severe-very gravelly and cobbly; slopes >15 percent	Severe-rocky; very gravelly and cobbly	Severe-rocky; very gravelly and cobbly	Severe-rocky; very gravelly and cobbly	Fair-ML material; limited depth	6
Graham cobbly clay loam, 5 to 25 percent slopes	Severe-shallow to bedrock	Severe-shallow to bedrock; high shrink-swell	Severe-shallow to bedrock	Severe-shallow to bedrock	Severe-clay texture; slopes >15 percent	Severe-clay texture; cobbles	Severe-clay texture; cobbles	Severe-clay texture, cobbles; slopes >15 percent	Poor-CH material	6
Rock Outcrop, 15 to 75 percent slopes	Severe-rock outcrop	Severe-rock outcrop	Severe-rock outcrop	Severe-rock outcrop	Severe-rock outcrop	Severe-rock outcrop	Severe-rock outcrop	Severe-rock outcrop	Poor-rock	6
(E3) Mirabal-Barkerville-Rock Outcrop										
Mirabal stony loam, 5 to 70 percent slopes	Severe-shallow to bedrock	Severe-shallow to bedrock	Severe-shallow to bedrock	Severe-shallow to bedrock	Moderate-cobbly. Severe-slopes >15 percent	Severe-cobbly	Moderate-cobbly. Severe-slopes >25 percent	Moderate-cobbly. Severe-slopes >15 percent	Fair-limited depth	6
Barkerville gravelly sandy loam, 5 to 60 percent slopes	Severe-shallow to bedrock	Severe-shallow to bedrock, slopes >15 percent	Severe-shallow to bedrock	Severe-shallow to bedrock	Moderate-gravelly. Severe-slopes >15 percent	Severe-gravelly	Moderate-gravelly. Severe-slopes >25 percent	Moderate-gravelly. Severe-slopes >15 percent	Poor-limited depth	6
Rock Outcrop, 15 to 75 percent slopes	Severe-rock outcrop	Severe-rock outcrop	Severe-rock outcrop	Severe-rock outcrop	Severe-crop outcrop	Severe-rock outcrop	Severe-rock outcrop	Severe-rock outcrop	Poor-rock outcrop	6
(E4) Faraway-Barkerville-Rock Outcrop										
Faraway very gravelly loam, 10 to 75 percent slopes	Severe-shallow to bedrock	Severe-shallow to bedrock	Severe-shallow to bedrock	Severe-shallow to bedrock	Severe-very gravelly	Severe-very gravelly	Severe-very gravelly	Severe-very gravelly	Poor-limited depth	6
Barkerville gravelly sandy loam, 5 to 60 percent slopes	Severe-shallow to bedrock	Severe-shallow to bedrock; slopes >15 percent	Severe-shallow to bedrock	Severe-shallow to bedrock	Moderate-gravelly. Severe-slopes >15 percent	Severe-gravelly	Moderate-gravelly. Severe-slopes >25 percent	Moderate-gravelly. Severe-slopes 15 percent	Poor-limited depth	6
Rock Outcrop, 15 to 75 percent slopes	Severe-rock outcrop	Severe-rock outcrop; slopes 15 to 75 percent	Severe-rock outcrop	Severe-rock outcrop	Severe-rock outcrop	Severe-rock outcrop	Severe-rock outcrop	Severe-rock outcrop	Poor-rock outcrop	6
(E5) Tortugas-Rock Outcrop										
Tortugas cobbly loam, 2 to 70 percent slopes	Severe-shallow to bedrock	Severe-shallow to bedrock; slopes >15 percent	Severe-shallow to bedrock	Severe-shallow to bedrock	Moderate-cobbly. Severe-slopes >15 percent	Severe-cobbly	Moderate-cobbly. Severe-slopes >25 percent	Moderate-cobbly. Severe-slopes >15 percent	Poor-limited depth, cobbly or stony	6
Rock Outcrop, 15 to 75 percent slopes	Severe-rock outcrop	Severe-rock outcrop; slopes 15 to 75 percent	Severe-rock outcrop	Severe-rock outcrop	Severe-rock outcrop	Severe-rock outcrop	Severe-rock outcrop	Severe-rock outcrop	Poor-rock outcrop	6
[redacted] LANDS										
(F1) Eroded and Gullied Calciorthids 15 to 60 percent slopes	Severe-slope exceeds 15 percent	Severe-slope exceeds 15 percent	Severe-where flooded. Limitations variable	Severe-slope exceeds 15 percent. Limitations variable	Severe-slope exceeds 15 percent; [redacted] areas subject to flooding	Severe-slope exceeds 15 percent	Severe-where slope exceeds 25 percent. Limitations variable	Severe-slope exceeds 15 percent	Good to Poor	6

1/ Estimated land class for gravity irrigation; based on criteria similar to that used by the Bureau of Reclamation.
Class 1 - Soils that are highly suitable for irrigation farming.
Class 2 - This class comprises soils of moderate suitability for irrigation farming.
Class 3 - Soils that are suitable for irrigation development but are approaching [redacted]ity for irrigation and are of distinctly restricted suitability.
Class 4 - Limited arable or special use soils.
Class 6 - Soils in this class are nonarable under existing conditions.

soil surveys are necessary for onsite planning and preparation or construction.

There are several modern published soil surveys in the study area. Modern survey mapping is complete in Santa Cruz and parts of Cochise and Pima counties. Local Soil Conservation Service field offices should be contacted for information on these surveys.

PLANT COVER

Native Vegetation

Vegetation types of the Santa Cruz-San Pedro River Basins correspond to those reported by Benson & Darrow, 1944 (25); Humphrey, 1958 (26); Humphrey, 1960 (27); and Nichol, 1952 (28). Vegetation types, as given in Table 2-12, combine pine and mixed conifer and oak woodland, pinyon-juniper, and chaparral which are given separate identities by others. Other vegetation types include riparian, Chihuahuan and Sonoran deserts, and grassland. The Vegetation, Cropland, Urban, and Mining Areas Map shows locations of native plant communities and areas where the plant cover has been cleared, displaced, or changed.

Photograph 1
Riparian vegetation (primarily mesquite) along water courses. Above the riparian, the vegetative zones grade in ascending order from Chihuahuan desert through desert grassland and oak woodland-chaparral to pine-mixed conifer high on Mt. Graham (background). *(SCS Photograph)*

Riparian

Riparian communities, occupying about 78,000 acres, are found mainly along streams and washes and on reservoir deltas throughout the study area. Tall, broadleaf deciduous dominant species include Arizona alder, Arizona sycamore, and aspen. Tall evergreens such as spruces, firs, and pines assume riparian growth habits where they grow along streams at the high mountain elevations. Other common riparian broadleaf trees include cottonwoods, willows, walnuts, ash, liveoaks, maples, mesquite, hackberries, and desert willows. Common shrubs include wild tobacco, chokecherry, seepwillow, catclaw, salt cedar, and elderberries. Understory grasses and herbaceous species are those common to adjoining vegetative type.

Photograph 2
Riparian vegetation along tributary of San Pedro River. *(SCS Photograph)*

Pine-Mixed Conifer Forest

Conifer forests occupy a little more than 130,000 acres. These areas are above 6,000 feet elevation on the scattered mountain ranges where annual precipitation averages more than 20 inches (see Table 2.12). Tall, long-lived evergreen tree dominants include ponderosa, Apache, Chihuahuan, and southwestern white pines (see Table 2.13). Douglas, white, and alpine firs, along with Engelmann spruce, usually grow on moist north facing slopes. Other common trees include aspen, Gambel oak, New Mexico locust, Arizona cypress, and Emory and Arizona white oaks. Of a large number of understory grass species, the most common include mountain muhly, Arizona fescue, pine dropseed, Junegrass, bromes, and several species of gramas. Other common herbaceous species include lupines, groundsels, vetches, asters, goldenrods, pussytoes and knotweeds.

TABLE 2.12

VEGETATION, CROPLANDS, URBAN, AND MINING AREAS

SANTA CRUZ-SAN PEDRO RIVER BASIN

Vegetation or Ground Cover Classification	Acres
Riparian Communities	77,921
Conifer Forest	
30 percent canopy or less	46,595
31 to 60 percent canopy	74,891
More than 60 percent canopy	9,088
Oak Woodland-Chaparral	
30 percent canopy or less	993,844
31 to 60 percent canopy	588,098
More than 60 percent canopy	36,807
Desert Grassland	3,093,172
Southern Desert	
Chihuahuan	613,261
Sonoran	3,843,384
Barren Lands	
Severely Eroded Land or "Badlands"	75,808
Willcox Playa--mostly dry lakebed	32,682
Croplands (including idle and abandoned land, farmsteads, highways, etc.)	646,782
Urban Lands	
Existing	75,093
Being Developed	311,599
Mining Lands and Communities	41,407
TOTAL	10,560,432

TABLE 2.13

AN ECOLOGICAL GROUPING OF COMMON PLANTS BY LIFE-FORMS--
SANTA CRUZ-SAN PEDRO RIVER BASINS

Scientific Name	Common Name	Vegetation Types 1/
	TREES	
Evergreen (Conifers and Broadleafed Species)		
	Tall (80-125 feet)	
Abies concolor	White fir	C
A. lasiocarpa	Alpine fir	C
Cupressus arizonica	Rough-bark Arizona cypress	C
Picea engelmannii	Engelmann spruce	C
Pinus ponderosa	Ponderosa pine	C
P. reflexa	Southwestern white pine	C
Pseudotsuga menziesii	Douglas fir	C
	Mid (50-79 feet)	
Juniperus deppeana	Alligator juniper	C-WC
Pinus cembroides	Mexican pinyon	C-WC
P. Chihuahuana	Chihuahua pine	C-WC
P. latifolia	Apache pine	C-WC
Quercus emoryi	Emory oak	C-WC
Q. grisea	Gray oak	WC
Q. hypoleucoides	Silverleaf oak	WC
Q. arizonica	Arizona white oak	C-WC
	Short (20-49 feet)	
Arbutus arizonica	Madrone	WC
Juniperus monosperma	One-seed juniper	WC
Olneya tesota	Ironwood	SD
Pinus edulis	Pinyon	WC
Quercus oblongifolia	Mexican blue oak	WC
Deciduous (Broadleafed Species)		
	Tall (60-80 feet)	
Alnus oblongifolia	Arizona alder	RI
Platanus wrightii	Arizona sycamore	RI
Populus tremuloides	Quaking aspen	C

1/ RI - Riparian; C - Conifer (includes meadows); WC - Oak woodlands, pinyon-juniper and chaparral; DG - Desert grasslands; SD - Southern Desert (includes Sonoran and Chihuahuan).

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TABLE 2.13 (Continued)

Scientific Name	Common Name	Vegetation Types 1/
	TREES (Continued)	
Deciduous (Broadleafed Species)(Continued)		
	Mid (40-59 feet)	
Acer negundo	Boxelder	RI
Juglans major	Arizona walnut	RI
Parkinsonia aculeata	Mexican paloverde	SD
Populus angustifolia	Narrowleaf cottonwood	RI
P. fremontii	Fremont cottonwood	RI
Quercus gambelii	Gambel oak	C
Salix laevigata	Red willow	RI
S. gooddingii	Goodding willow	RI
	Short (20-39 feet)	
Acer glabrum	Rocky Mt. maple	RI
Alnus tenuifolia	Mountain alder	RI
Celtis reticulata	Hackberry	RI
Cercidium floridum	Blue paloverde	SD
C. microphyllum	Yellow paloverde	SD
Chilopsis linearis	Desert willow	SD-WC
Fraxinus velutina	Velvet ash	RI
Prosopis juliflora	Common mesquite	RI-SD-DC
Prunus virginiana	Choke-cherry	C
Robinia neomexicana	New Mexican locust	C
	SHRUBS	
Evergreen	Tall (13-30 feet)	
Cercocarpus betuloides	Birchleaf mountain mahogany	WC
Nicotiana glacua	Tree tobacco	SD-RI
Prunus virens	Southwestern choke-cherry	RI
Quercus turbinella	Shrub liveoak	WC
Rhamnus californica	California buckthorn	WC
Rhus ovata	Mountain laurel (sugar sumac)	WC
	Mid (6-12 feet)	
Arctostaphylos pringlei	Manzanita	WC
Baccharis glutinosa	Seepwillow	RI
B. sarothroides	Desertbroom	RI
Berberis haematocarpa	Berberis	WC
Cercocarpus montanus	Mountain mahogany	WC

Scientific name	Common Name	Vegetation Types 1/
Evergreen (Continued	SHRUBS (Continued)	
	Mid (Continued)	
Cowania mexicana	Cliffrose	WC
Ephredra trifurca	Mormon tea	SD-DG
Garrya flavescens	Yellowleaf silktassel	WC
Garrya wrightii	Wright silktassel	WC
Larrea tridentata	Creosotebush	SD
Rhamnus crocea	Holyleaf buckthorn	WC
Simmondsia chinensis	California coffeeberry, jojoba	WC
	Short (1-5 feet)	
Arctostaphylos pungens	Pointleaf manzanita	WC
Baccharis pteronioides	Yerba-de-pasmo	RI
Berberis repens	Berberis	WC
Ceanothus fendleri	Fendler ceanothus	C-WC
C . greggii	Desert ceanothus	WC
Chrysothamnus nauseosus	Rabbitbrush	C-WC
Encelia farinosa	Brittlebush	SD
Eriodictyon angustifolia	Yerba-santa	WC
Fallugia paradoxa	Apache-plume	WC
Flourensia cernua	Tar-bush	SD
Franseria deltoidia	Bur-sage	SD
F. dumosa	White bur-sage	SD
Mortonia scabrella	Mortonia	SD
Deciduous		
	Tall (13-20 feet)	
Acacia Greggii	Catclaw	SD-RI
Morus microphylla	Texas mulberry	RI-WC
Prunus emarginata	Bitter cherry	C
P. virginiana	Choke-cherry	RI-C
Tamarix pentandra	Saltcedar, Tamarisk	RI
	Mid (6-12 feet)	
Acacia constricta	Acacia, whitethorn	SD
Anisacanthus Thurberi	Desert honeysuckle	SD
Ceanothus integerrimus	Deerbrush	WC
Condalia lyciodes	Graythorn or lotebush	SD-WC
C. Spathulata	Squaw-bush	SD-WC
Cornus stolonifera	Red-osier dogwood	RI
Fendlera rupicola	Cliff fendlerbush	WC
Fouquieria splendens	Ocotilla	SD

TABLE 2.13 (Continued)

Scientific Name	Common Name	Vegetation Types 1/
	SHRUBS (Continued)	
Deciduous (Continued)		
	Mid (Continued)	
Hymenoclea monogyra	Burrobrush	SD
Mimosa biuncifera	Wait-a-bit	SD
Rubus neomexicanus	Thimbleberry	SD
Sambucus neomexicana	Elderberry	C-RI
	Short (1-5 feet)	
Aplopappus heterophyllus	Rayless goldenrod, jimmy-weed	SD-DG
A. laricifolius	Turpentine bush	SD-DG
Atriplex canescens	Four-wing saltbush, chamiza	WC-C-DG-SD
Calliandra eriophylla	Fairy duster	SD-WC-DG
Carlowrightia arizonica	Carlowrightia	SD-DG
Eriogonum wrightii	Shrubby buckwheat	SD-WC-DG
Koeberlinia spinosa	Crucifixion thorn	SD
Krameria parvifolia	Range ratany	SD-WC-DG
Parthenium incanum	Mariola	SD
Penstemon microphyllus	Littleleaf penstemon	SD-WC
Rhus glabra	Smooth sumac	WC
R. microphylla	Sumac	SD
R. trilobata	Skunkbush, squawberry	WC
R. radicans	Poison ivy	WC-C
Ribes aureum	Golden currant	WC
R. pinetorum	Orange gooseberry	C
R. quercetorum	Oakwoods gooseberry	SD
Rosa arizonica	Arizona rose	RI-C
R. fendleri	Fendler rose	C
Rubus arizonensis	Arizona dew-berry	WC
Symphoricarpus oreophilus	Mountain snowberry	C
S. rotundifolius	Roundleaf snowberry	C
Other Woody Plants		
Agave palmeri	Palmer agave, century plant	C-WC
A. Parryi	Parry agave, mescal	C-WC-SD-DG
A. Schottii	Agave, amole	SD-WC-DG
Carnegiea gigantea	Saguaro	SD-DG
Dasylirion Wheeleri	Sotol	SD-WC-DG
Nolina microcarpa	Bear-grass	SD-WC-DG
Opuntia acanthocarpa	Buckhorn cholla	SD-DG
O. bigelovii	Jumping cholla, teddybear	SD-DG
O. fulgida	Cholla	SD-DG
O. leptocaulis	Christmas cactus	SD
O. versicolor	Staghorn cholla	SD
Yucca baccata	Blue yucca	WC-DG
Y. elata	Soaptree yucca	SD-WC-DG
Y. schottii	Hoary yucca	SD-WC-DG

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TABLE 2.13 (Continued)

Scientific Name	Common Name	Vegetation Types 1/
	HERBACEOUS PLANTS	
Tall Grasses & Grass-like Plants (Perennial - More than 18 inches)		
Agropyron trachycaulum	Slender wheatgrass	C
Agrostis palustris	Creeping bent	C
Andropogon barbinodis	Cane bluestem	SD-WC
Bromus ciliatus	Fringed brome	C
B. marginatus	Mountain brome	C
Carex wootonii	Wooton sedge	C
Calamagrostis canadensis	Northern reedgrass	C
Eragrostis chloromelas	Boer lovegrass	WC-DG-SD
Eragrostis curvula	Weeping lovegrass	WC-DG
Eragrostis Lehmanniana	Lehman lovegrass	SD-WC-DG
Glyceria borealis	Northern mannagrass	C
G. elata	Tall mannagrass	C
Hilaria rigida	Big galleta	SD-DG
Hordeum brachyantherum	Meadow barley	C
Leptochloa dubia	Green sprangletop	SD-WC-DG
Muhlenbergia emersleyi	Bullgrass	C-WC
M. longiligula	Longtongue muhly	C
M. rigens	Deergrass	C-WC
Phleum pratense	Timothy	C
Sporobolus contractus	Spike dropseed	C
Sporobolus wrightii	Sacaton	SD-DG
Stipa pringlei	Pringle needlegrass	C
Scirpus microcarpus	Bullrush	C
Midgrasses and Grass-like Plants (Perennial) (8-18 inches)		
A. smithii	Western wheat	C-WC
Agrostis scabra	Rough bent	C
Alopecurus geniculatus	Water foxtail	C
Andropogon cirratus	Texas bluestem	C
A. scoparius	Little bluestem	C-WC
Aristida divaricata	Poverty three-awn	WC-DG
A. glabrata	Santa Rita three-awn	SD-DG-WC
A. purpurea	Purple three-awn	SD-DG-WC
Bouteloua curtipendula	Side-oats grama	SD-WC-C
B. eriopoda	Black grama	SD-DG-WC
B. filiformis	Slender grama	SD-DG
B. rothrockii	Rothrock grama	SD-DG
Bromus anomalus	Nodding brome	C
Carex rostrata	Beaked sedge	C
Cyperus wrightii	Sedge	WC
C. manimae	Sedge	WC
Eragrostis intermedia	Plains lovegrass	WC
Festuca arizonica	Arizona fescue	C
Heteropogon contortus	Tanglehead	SD-DG

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Scientific Name	Common Name	Vegetation Types 1/
	HERBACEOUS PLANTS (Continued)	
Midgrasses and Grass-like Plants (Perennial)(8-18 inches) (Continued)		
Hilaria jamesii	Galleta	WC
H. mutica	Tobosa	SD-WC
Juncus saximontanus	Mountain rush	C
Muhlenbergia montana	Mountain muhly	C
M. porteri	Bush muhly	SD-DG-WC
M. wrightii	Spike muhly	C-WC
Oryzopsis hymenoides	Rice grass	C-WC
Panicum bulbosum	Bulb panicum	WC
P. obstusum	Vine mesquite	SD-WC
Phleum pratense	Timothy	C
Poa fendleriana	Mutton grass	C-WC
P. longiligula	Longtongue muttongrass	C-WC
P. pratense	Kentucky bluegrass	C
Sitanion hystrix	Squirreltail	C-WC
Sporobolus cryptandrus	Sand dropseed	SD-WC-C
Stipa columbiana	Needlegrass	C-WC
S. comata	Needle & thread	C-WC
Trichachne californica	Arizona cottontop	SD-DG-WC
Tridens mutica	Slim tridens	WC
T. pilosus	Hairy tridens	SD-DG-WC
Short Grasses (Perennial, 2-8 inches)		
Aristida longiseta	Red three-awn	C-WC
Blepharoneuron tricholepis	Pine dropseed	C-WC
Bouteloua chondrosioides	Sprucetop grama	SD-WC
B. gracilis	Blue grama	C-WC-DG
B. hirsuta	Hairy grama	C-WC
Hilaria belangeri	Curly mesquite	SD-WC-DG
Koeleria cristata	Prairie Junegrass	C
Lycurus phleoides	Wolftail	SD-WC-DG
Muhlenbergia repens	Creeping muhly	C-WC
Schedonnardus paniculatus	Tumblegrass	C-WC-SD-DG
Sporobolus interruptus	Black dropseed	C-WC
Tall, Mid & Short Forbs (Perennial, variable heights)		
Abronia spp.	Sand verbena	SD-DG-WC-C
Argemone spp.	Prickle-poppy	DG-WC-C-SD
Artemesia spp.	Sage	WC
Asclepias spp.	Milkweed	SD-DG-WC-C
Aster spp.	Aster	C-WC
Astragalus spp.	Milkvetch	C-WC
Boerhaavia spp.	Spiderling	SD-DG-WC-C

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TABLE 2.13 (Continued)

Scientific Name	Common Name	Vegetation Types 1/
	HERBACEOUS PLANTS (Continued)	
Tall, Mid & Short Forbs (Perennial, variable heights) (Continued)		
Castilleja spp.	Paintbrush	C
Cerastrum brachypodum	Cerastrum	C
Chrysopsis spp.	Goldenaster	SD-DG-WC-C
Cirsium spp.	Thistles	C
Croton spp.	Croton	SD-DG-WC
Datura meteliodes	Jimson weed	SD-DG-WC-C
Desmanthus cooleyi	Bundleflower	WC
Desmodium spp.	Tickle clover	SD-WC
Erigeron spp.	Fleabane	WC-C
Eriogonum spp.	Eriogonum	WC
Erysimum spp.	Western wallflower	SD-DG-WC-C
Euphorbia spp.	Euphorbia	WC
Evolvulus arizonicus	Arizona evolvulus	WC
Franseria spp.	Bur-sage	SD-WC
Gaura spp.	Gaura	SD-WC
Gentiana spp.	Gentian	C
Geranium spp.	Geranium	C-WC
Gilia spp.	Gilia	C
Helenium Hoopesii	Sneezeweed	C
Hibiscus spp.	Rosemallow	SD-WC
Hymenopappus lugens	Hymenopappus	WC-C
Hypericum formosum	St. Johnswort	WC-C
Ipomea spp.	Morning glory	C-WC
Iris missouriensis	Iris	C
Jatropha macrorhiza	Sangre-de-drago	SD-WC-C
Kallstroemia grandiflora	Mexican poppy	SD-WC
Lathyrus spp.	Peavine	C-WC
Lepidium spp.	Pepper-grass	C
Linum lewisii	Prairie flax	WC-C
Lithospermum multiflorum	Puccoon	C-WC
Lotus spp.	Deervetch	SD-WC-C
Lupinus spp.	Lupinus	SD-WC-C-DG
Marrubium vulgare	Common hoarhound	WC
Mimulus spp.	Monkeyflower	SD-C
Nicotiana spp.	Tobacco	SD-WC-C
Penstemon spp.	Penstemon	SD-WC-C-DG
Petalostemon spp.	Prairie clover	C-WC
Physalis spp.	Ground cherry	SD-WC-C
Polygonum spp.	Knotweeds	SD-WC-C-DG
Psoralea tenuiflora	Scurfpea	WC
Pseudocymopteris montanus	Pseudocymopteris	C
Ranunculus spp.	Buttercup	C
Rumex spp.	Docks	SD-WC-C
Senecio spp.	Groundsels	SD-DG-WC-C

TABLE 2.13 (Continued)

Scientific Name	Common Name	Vegetation Types 1/
	HERBACEOUS PLANTS (Continued)	
Tall, Mid & Short Forbs (Perennial, variable heights) (Continued)		
Sida spp.	Sida	SD-DG-WC-C
Solidago spp.	Goldenrod	WC-C
Sphaeralcea spp.	Globemallow	SD-DG-WC-C
Thalictrum Fendleri	Meadowrue	C
Thelypodium spp.	Thelypodium	SD-WC
Trifolium spp.	Clovers	SD-DG-WC-C
Valeriana spp.	Valerian	WC-C
Verbena spp.	Verbena	SD-DG-WC-C
Vicia	Vetch	C
Prostrate Grasses & Forbs (Perennial, less than 2 inches)		
Achillea lanulosa	Yarrow	C-WC
Agoseris spp.	Wild dandelions	SD-DG-WC-C
Astragulus humistratus	Prostrate loco	C-WC
Antennaria spp.	Pussytoes	C
Arenaria confusa	Sandwort	C
Erigeron spp.	Fleabanes	WC-C
Mollugo spp.	Mollugo	SD-WC
Oxalis spp.	Woodsorrels	C
Plantago spp.	Plantains	SD-DG-WC-C
Potentilla spp.	Cinquefoils	C-WC
Solidago spp.	Goldenrods	C-WC
Taraxacum spp.	Common dandelion	C-WC
Tridens pulchellus	Fluffgrass	SD-WC-DG
	SHORT-LIVED HALF-SHRUBS	
Chrysothamnus spp.	Rabbit brush	C-WC
Cutierrezia sarothrae	Snakeweed	SD-DG-WC-C
Mendora scabra	Rough mendora	SD-DG-WC-C
	ANNUAL GRASSES & FORBS	
Amaranthus spp.	Amaranth	C-WC
Amsinckia spp.	Fiddle-neck	SD-DG
Aplopappus gracilis	Annual burroweed	SD-WC-DG
Aristida adscensionis	Annual three-awn	SD-WC-DG
Bouteloua aristidoides	Needle grama	DG-WC
B. barbata	Six-weeks grama	DG-WC
B. simplex	Annual grama	C
Bromus tectorum	Cheatgrass	C-WC

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TABLE 2.13 (Continued)

Scientific Name	Common Name	Vegetation Types 1/
	ANNUAL GRASSES & FORBES (Continued)	
Chenopodium spp.	Goosefoot	C-WC
Chloris virgata	Finger grass	SD-DG-WC
Eragrostis cilianensis	Annual lovegrass	SD-WC
Erigeron flagellaris	Trailing daisy	WC-C
Erodium cicutarium	Filaree	SD-DG-WC
Eschscholtzia mexicana	California-poppy	SD-DG-WC
Euphorbia spp.	Spurge	SD-DG-WC-C
Festuca octoflora	Six-weeks fescue	SD-DG-WC
Lepidium spp.	Pepper-grass	WC-C
Lesquerella spp.	Bladder-pod	SD-DG-WC-C
Lupinus kingii	Annual lupine	C
Lupinus spp.	Annual lupine	SD-DG-WC
Muhlenbergia microsperma	Annual muhly	SD-DG-WC
Orthocarpus purpurascens	Owl clover	SD
Plagiobothrys spp.	Plagiobothrys	SD
Plantago insularis	Indian wheat	SD-DG
Ploygonum spp.	Knotweeds	C-WC
Proboscidea spp.	Devils-claws	SD-DG
Salvia spp.	Sage	SP-DG-WC-C
Schismus barbatus	Schismus	SD
Sporobolus microspermus	Annual dropseed	C
Xanthium spp.	Cocklebur	SD-DG-WC-C

Oak Woodland-Chaparral

Oak Woodland-chaparral includes chaparral, oak, and pinyon-juniper woodlands. This type covers a little more than 1,600,000 acres, mainly from 4,000 to 6,500 feet elevation. On north slopes, woodland-chaparral may drop below 4,000 feet, and it may be found above 6,500 feet on south slopes. Woodland chaparral is located below the conifer forest and above the desert and desert grasslands. The average annual precipitation

Photograph 3
Oak Woodland-chaparral in Huachuca Mountains.
Conifer forest at top. *(FS Photograph)*

ranges between 14 and 20 inches. Oak Woodland-chaparral is dominated by such common overstory of long-lived mid and short evergreen trees as Emory, Gray, silver leaf, Arizona, and Mexican blue oaks; alligator and one-seed junipers; Arizona cypress; and two species of pinyons. There are few deciduous trees (Table 2.13). The most common tall, mid, and short evergreen shrubs include manzanitas, mountain mahogany, California buckthorn, shrub liveoak, cliffrose, silktassel, and ceanothus. The few deciduous shrubs include squaw bush, four-wing saltbush, fairy duster, and shrubby buckwheat. Other common woody species include yuccas, agaves, and bear-grass.

Although ground cover is sparse under woodland-chaparral stands with canopies in excess of 60 percent, a large number of perennial grassses and forbs are found where canopies are less than 30 percent. A few of the common understory grasses and forbs include three-awns, several species of muhly, sideoats and other species of gramas, deergrass,

Photograph 4
Chaparral on Baboquivari Mountains (61-100% canopy).
(FS Photograph)

bullgrass, sprangletop, lovegrass, Junegrass, goldeneye, deer vetch, prickly poppy, asters, fleabanes, buckwheats, lupines, and groundsels. Annual grasses and forbs are found on disturbed areas in years of above average precipitation.

Photograph 5
Oak woodland near Patagonia. *(SCS Photograph)*

Desert Grassland

Desert grasslands occupy a little more than three million acres below the woodland-chaparral zone at elevations ranging mainly between 3,000 and 5,000 feet. The prevailing life-forms are tall, mid, and short perennial grasses and forbs including sacaton, tobosa, beard grass, three-awns, sideoats grama, black grama, blue grama, curly mesquite, verbena, fleabanes, and Mexican poppy. Low shrubs that are common in desert grasslands include false mesquite and shrubby buckwheat. Annual grasses and forbs are also common and become most abundant during winter or summer seasons of above average rainfall. Short and prostrate grasses and forbs such as curly mesquite, creeping muhly, plantains, and fluffgrass make up an important part of desert grasslands. They increase when tall and mid grasses are overgrazed. Annual three-awns, annual burroweed, six-weeks grama, needlegrass, lupines, prickly poppy, careless weed, and annual muhly are most abundant on overgrazed ranges in years of above average winter and summer rainfall.

Photograph 6
Desert grassland in Douglas Basin. *(SCS Photograph)*

Southern Desert

Southern desert occupies a little more than 4.4 million acres, of which about 600,000 acres are identified as Chihuahuan Desert and about 3.8 million acres as Sonoran Desert (25) (29) (30).

The Chihuahuan Desert blends with the Sonoran Desert north of Benson and extends southward along the San Pedro River to the International Boundary and eastward to the San Bernardino Valley. Large "islands" of Chihuahuan Desert occur throughout the Sulphur Springs Valley on limestone soils and hills and are surrounded by desert grasslands. This

vegetation type is usually found at elevations between 3,800 feet to 5,000 feet. Limited extensions are found down to 3,200 feet along the San Pedro River and as high as 6,000 feet in the Swisshelm Mountains northeast of Douglas. Average annual precipitation at representative stations in the Chihuahuan Desert ranges from 10 to 16 inches. Average annual temperatures range between 60 and 65 degrees.

The Chihuahuan Desert vegetation differs from the Sonoran Desert by the higher density of shrubs and fewer cacti. Common shrubs include creosote bush, whitethorn, Mortonia, tar bush, mariola, crucifixion thorn, graythorn, mesquite, yuccas, sotol, saltbush, and catclaw.

Photograph 7
Chihuahuan Desert in Douglas Basin. *(FS Photograph)*

Elevations and rainfall for the Chihuahuan Desert are similar to those of the surrounding desert grassland areas. Areas such as those surrounding Tombstone have shown a recorded shift from desert grassland to Chihuahuan Desert. Because of a close association with the desert grassland type, areas of Chihuahuan Desert that have been cleared of brush and re-seeded have been converted to grassland.

The Sonoran Desert occupies the lower parts of the San Pedro Valley, including the lower end of Aravaipa Creek, and the lower parts of the Santa Cruz River and Santa Rosa Wash drainages. Elevations range from about 1,000 feet near the confluence of the Santa Cruz and Gila Rivers to about 4,000 feet where the upper slopes of the desert blend into the major mountain ranges.

The Sonoran Desert receives the least precipitation of the vegetation types. Average annual rainfall ranges from 8 to 12 inches. Average annual temperatures range from 67 to 70 degrees Fahrenheit.

The vegetation is characterized by widely-spaced, woody, and succulent types of perennial plants that are well adapted to conserving

Photograph 8
Sonoran Desert in Tucson Mountains. *(FS Photograph)*

water during the long periods of little rain. Small trees that are found growing along the desert washes include paloverde, ironwood, and mesquite. Common shrubs and cacti having more general distribution include creosote bush, saguaro (giant cactus), chollas, pricklypear, hedgehog, brittle bush, jojoba, bursage, and catclaws. Open spaces between perennial trees, shrubs, and cacti are bare most of the time but can become completely covered with annuals during infrequent years when winter and/or summer rainfall is unusually high.

Barren Lands

Barren areas of the Santa Cruz-San Pedro River Basin include almost 76,000 acres of severely eroded land or "badlands" and areas with little or no protective vegetation. The "badlands" occur mostly along the San Pedro River. In addition, the barren Willcox Playa is a lake bed covering 32,682 acres. Most of the playa is usually dry.

Hydro-Ecological Relationships

Prevailing plant life-forms that dominate a vegetation type reflect the status in a hydro-ecological classification. Size and density of cover can be related to plant successions and hydrologic functions. The life-form classification, listing about 300 species of plants, is given in Table 2.13. At the top of the life-form classification, tall, long-lived, evergreen conifers such as pines have the greatest ecological capacity to displace subordinate perennial and annual species. At the bottom of this classification, annuals have the least displacement capacity. Hydrologically, tall evergreen conifers with long growth periods intercept more snow and rain and use more water by evapotranspiration than smaller deciduous species with short growth periods.

Comparison of 1969 and 1892 photographs has indicated that riparian and phreatophyte vegetation has become established along some drainages (31). Deltas and shores of lakes such as Pena Blanca and Parker Canyon provide the moist habitats needed by cottonwoods, willows, and saltcedars.

By growing along stream courses, around lakes and ponds, and on reservoir deltas, riparian and phreatophyte communities get more water than that supplied only by precipitation (32). Annual water use ranges from 2 to 6 acre-feet per acre (33). Growing on deposited sediments, stands of riparian and phreatophyte species have developed along the banks of the Gila River above Ashurst-Hayden diversion. Deposition of sediment combined with growth of saltcedar and seepwillow have closed in on Picacho Reservoir to the extent that restoration of storage has necessitated clearing and dredging.

A hydrologic characteristics of evergreen conifers is that interception of snow and rain increases as canopy densities of tree stands increase over 30 percent. Evergreen growth habits of conifer forests result in large losses of water by evapotranspiration. With selective logging, estimated annual water yields to streams from conifer communities range from 2 to 3¼ inches.

Removal of conifer forest dominants such as pines, spruces, and firs by logging or wildfires results in the release of sprouting understory species such as aspen, oaks, locust, alligator juniper, chaparral species, grasses, and forbs. Successional re-establishment of evergreen dominants takes more years after wildfire than after logging because of more complete destruction of trees.

Non-sprouting overstory trees and shrubs of woodland-chaparral suffer the most severe damage from destructive wildfires. By comparison, sprouting species begin regrowth during the first season following fire. Since there are few sources of grass and forb seeds under dense woodland-chaparral stands, natural recovery of ground cover is very slow after destructive wildfires. Re-establishment of a protective ground cover can be accelerated by reseeding.

Woodland-chaparral stands with more than 30 percent canopy intercept and dissipate through evapotranspiration most of the 14-20 inches of precipitation they receive. Evapotranspiration is high where annual mean temperatures range from 50 to 65 degrees Fahrenheit and maximum summer temperatures range from 75 to 85 degrees Fahrenheit. Precipitation over woodland-chaparral areas yield an inch of surface flow as an annual average. Evapotranspiration in woodland-chaparral stands with less than 30 percent canopy is probably similar to that of grasslands.

Invasions of desert grasslands by mesquite, burroweed, pricklypear, cholla, agaves, and yuccas have been related to fire protection and the reduction of herbaceous fuels by heavy grazing (26) (27) (34) (35). However, invasions of ungrazed grasslands by overstory trees and shrubs indicate this type of successional displacement can be a natural function of ecological dominance and can occur independent of grazing. In the absence of grazing, accumulation of grass fuels favors natural wildfires that kill invading overstory trees and shrubs and consequently maintains the grassland type.

Desert grasslands receive from 12-18 inches average annual precipitation. Compared to tree and shrub communities, desert grasslands have much less foliage to intercept rain during rainfall periods. Transpiration losses of grasses and forbs are much less than that of perennial tree and shrub types because grasses and forbs die back to the soil surface annually. With low rainfall and high evaporation, average annual water yields are generally less than one inch.

Sonoran and Chihuahuan segments of the Southern Desert are subject to little successional change from natural wildfires. Only in those rare years when summer or winter precipitation is unusually high can the growth of annual herbaceous plants produce enough fuels to carry wildfires. When they do occur, wildfires kill significant amounts of overstory trees, shrubs, cacti, yuccas, and century plants and release understory annual and perennial grasses and forbs.

Because surface areas between widely-spaced woody and succulent desert plants are bare over prolonged periods, high rates of runoff occur during high intensity thunderstorms. Surface layers of rocks and pebbles called erosion pavement or "desert pavement" provide considerable protection against erosion during these periods. The largely barren areas along the San Pedro River have the least chance for natural re-establishment of vegetation because of severe erosion.

Rare and endangered plants, along with their locations in the study area, are listed in Table 2-14.

Photograph 9
Urban land and cropland at Benson. *(FS Photographs)*

Croplands

Native vegetation has been displaced on about 647,000 acres by croplands (farmed, idle, and abandoned), homesteads, ditches, and adjacent roads. Principal crops grown are cotton, small grains, hay, pasture, vegetables, deciduous fruits, and pecans. Sparse stands of annuals and

TABLE 2.14

RARE AND ENDANGERED PLANTS OF

SANTA CRUZ-SAN PEDRO RIVER BASINS

Plant Name Scientific	Common	Location Where Plant is Found
	Trees	
Bursera fagaroides	Elephant tree	Baboquivari and Estrella Mts.
Pinus latifolia	Apache pine	Chiricahua and Dragoon Mts.
	Shrubs	
Atriplex Griffithsii	Salt-bush	Willcox Area
Choisya mollis	Star leaf	Southern Arizona
Cissus trifoliata	Grape family	Santa Cruz and Pima Counties
Cordia parvifolia	Borage family	South of Tucson
Diphysa Thurberi	Diphsa	Near Huachuca Mts.
Fraxinus Gooddingii	Goodding ash	Cochise County
Lysiloma Thornberi	Lysiloma	Pima County
Manihot angustiloba	Cassava	Mountains of Cochise, Pima, & Santa Cruz Counties
Manihot Davisiae	Cassava	Baboquivari and Santa Catalina Mts.
Mimosa laxiflora	Mimosa	Papago Indian Reservation
Sophora formosa	Sophora	Pinaleno Mts.
	Succulents	
Cereus Diguettii	Willcoxia	Sonoran Desert
Cereus giganteus	Saguaro	Sonoran Desert
Cereus Greggii	Night blooming cereus	Sonoran Desert
Echinocactus sp	Barrel cactus	Sonoran Desert
Echinocereus ledingii	Leding Hedgehog	Pinaleno Mts.
Echinocereus pectinatus	Comb hedgehog	Southeastern Arizona border
Mammillaria Macdougalii	Cream cactus	Near Tucson
Mammillaria recurvata	Fishhook cactus	Santa Cruz County
	Grasses and Grass-like Plants	
Andropogon Wrightii	Broom Sedge	Santa Cruz County
Bromus texensis	Brome	Huachuca Mts.
Cathestecum erectum	Falsegrama	Southern Arizona
Muhlenbergia dubioides	Muhly	Santa Rita and Santa Catalina Mts.
Muhlenbergia tenuifolia	Muhly	Dragoon Mts.
Setaria villosissima	Bristlegrass	Southern Arizona

Page 1 of 2 pages

Table 2.14 (Cont.)

RARE AND ENDANGERED PLANTS OF

SANTA CRUZ-SAN PEDRO RIVER BASINS

Plant Name Scientific	Common	Location Where Plant is Found
	Broadleaf Forbs	
Abutilon Parishii	Indian Mallow	Santa Catalina Mts.
Amoreuxia Gonzalegii	none	Santa Rita Mts.
Cardiospermum Halicacabum	Balloon vine	Chiricahua Mts.
Corchorus hirtus	none	Mexican Border
Desmanthus bicornutus	Bundle flower	Santa Cruz County
Gentiana grandis	Gentian	Huachuca and Santa Rita Mts.
Gentiana Wrightii	Gentian	Santa Cruz County
Hypoxis mexicana	Goldeneye	Huachuca Mts.
Ibervillea tenuisecta	none	Guadalupe Canyon
Ipomoea egregia	Morning Glory	Huachuca Mts.
Ipomoea Lemmoni	Morning Glory	Huachuca Mts.
Liaeopsis recurva	Lilaeopsis	Huachuca Mts. and near Tucson
Lilium Parryi	Lily	Huachuca and Santa Rita Mts.
Nemacladus longiflorus	Bellflower	From Tucson to Sells
Passiflora byronioides	Passion Flower	Santa Cruz County near Ruby
Phaseolus atropurpureus	Bean	Baboquivari and Coyote Mts.
Pherotrichis Balbisii	Milkweed	Huachuca Mts.
Potentilla albiflora	none	Pinaleno Mts.
Rhynchosia rariflora	Rosary Bean	Santa Cruz County
Rumex orthoneurus	Dock	Chiricahua Mts.
Spiranthes parisitica	Lady's-tresses	Santa Catalina Mts.
Stevia visicida	Stevia	Huachuca Mts.
Streptanthus Lemmoni	Twist flower	Santa Catalina Mts.
Tumamoca Macdougalii	Gourd	Near Tucson

This list was compiled by State and Federal agencies with "Arizona Flora" by Kearney and Peebles and reports by Howell and McClintock as basic references.

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short-lived half-shrubs have become established on the abandoned crop-lands and are characteristic of early stages of plant succession.

Urban Lands

Existing urban lands (Table 2.12, page 2.74) presently occupy 75,093 acres in the Santa Cruz-San Pedro River Basin. Native vegetation in such areas has been displaced by concrete, asphalt, lawns, ornamentals, fruit trees, and buildings. More than 311,000 acres have been platted for residental and business communities.

Mining Lands and Communities

Mining lands and communities, totaling 41,407 acres, have displaced native vegetation in the study area. Included are large open pits and areas covered with excavated materials and mine tailings.

Photograph 10
Open-pit mining near Sahuarita. *(FS Photograph)*

FISH AND WILDLIFE

Fish

Fisheries of the study area are quite diverse in character even though limited in extent. Lakes and streams with permanent waters that maintain a fishery are covered in the Water Resources section, pages 2.35 through 2.39.

Surface waters vary in characteristics from cold mountain streams to intermittent desert washes and from clear mountain reservoirs to murky desert tanks. Generally, water temperatures increase with decreasing elevations. Surface water occurring above 5,000 feet maintains conditions conducive to the production of cold water fish species such as rainbow trout. Below 5,000 feet average water temperature increases, thus producing a fishery consisting of bass, catfish, bluegill, and other warm water species. Some waters of the lower desert areas maintain water temperatures sufficiently high to support populations of tropical fishes such as the Mosambique mouthbrooder (tilapia).

The arid character of the study area provides the basic setting for some unique aquatic habitat conditions. Springs and seeps tend to be far removed from other permanent water sources. Under these conditions, remnants of near extinct fish populations still persist. An example of such a condition is Monkey Springs near Patagonia with its population of Monkey Springs pupfish.

Fish species known to inhabit the waters of the study area are listed in Table 2.15.

Wildlife

Vegetation in the study area, as described in detail in the preceding sections, provides a wide diversity of wildlife habitat types. The extremes range from nearly barren, eroded badlands along the San Pedro River, through Sonoran and Chihuahuan Deserts, desert grasslands and woodland-chaparral, to conifer forest. Local variations, both natural and manmade, occurring in nearly all of these major plant communities add much to the diversity in these communities. These include developed cropland, desert riparian vegetation, streamside riparian vegetation, mountain grasslands in openings of forest canopy cover, and many others varying greatly in both effect and extent of coverage. These factors combine to produce a wide variety of wildlife habitat types.

Approximately 433 species and sub-species of terrestrial vertebrates inhabit the study area. Of these, 252 species are birds, 92 species are mammals, and 89 species are reptiles and amphibians. Detailed lists of these vertebrates are contained in Tables 2.16, 2.17, and 2.18. In addition to common and scientific names, these lists contain information on habitat type requirements for each species and potential acreages of each habitat type. Figure 22, Distribution of Big Game, and Figure 23, Distribution of Small Game, show the range of most resident game species and follow these tables.

Birds in the study area can further be broken down into several groups or types. Under Arizona law and regulations, thirty species are classified as game, of which 19 species are migratory waterfowl, six species are upland game, four species of migratory upland game, and one species is big game.

Non-game birds include 22 species of birds of prey, 23 species of shore and wading birds, and 177 species of song and insectivorous birds.

Twenty-one species of mammals are taken either as game for sport, or for fur. The seven species of mammals classed as big game are black bear, mountain lion, javelina, mule deer, whitetail deer, pronghorn antelope, and bighorn sheep. The five species classes as small game are the red squirrel, Arizona gray squirrel, Abert squirrel, eastern cottontail, and desert cottontail.

Mammals taken for sport or fur include small predatory animals as well as the customary fur animal species. Predatory species taken are the coyote, kit fox, gray fox, and bobcat. Fur animal species include the racoon, coati, ringtail cat, four species of skunk, badger, beaver, and muskrat.

In addition to the above, there are about 71 non-game species of mammals seldom taken by man; many are seldom observed by man. These include two species of shrews; 20 species of bats; one species of weasel; two species of cats; five species of ground squirrels and chipmunks; one species of prairie dog; thirteen species of pocket mice, pocket gophers, and kangaroo rats; seventeen species of mice and rats; one species of porcupine; and two species of hares.

One of the 89 species of reptiles and amphibians, the bullfrog, is considered to be a game species. Non-game species include one species of salamander; six species of frogs and toads; five species of turtles; 24 species of lizards of which one, the Gila Monster, is venomous; two species of skunks; and 40 species of snakes. Fifteen species of these snakes are venomous and include one species of coral snake and ten of rattlesnakes.

The wide range of altitude, precipitation, temperature, and geologic circumstances within the study area combine to produce an equally wide range of vegetative conditions. Wildlife habitat in the various types of plan cover will generally vary from very good to poor, depending upon local conditions.

Preceding the 1970 base year, the 1969 drought caused a decline in habitat quality. These declines are not indicative of a normal trend in productivity levels. The reduced productivity level can be most easily exemplified comparing reduction of harvest of big game species, since survey data are more detailed for these species. The 1970 harvest for the study area was down 11% for javelina, 12% for deer, 31% for turkey, 41% for antelope, and 48% for bighorn sheep compared to the 1968 harvest.

Drought is not, however, the only factor which results in reduced wildlife productivity. Other factors influencing these trends in the study area include availability of permanent water, increased human activity, farming and ranching practices, commercial logging practices, off-road vehicle useage, vegetative manipulation programs, urbanization, utility and transportation rights-of-way, construction, water development projects, mining activity, disease, predation, etc. The influence

which these activities have on any one wildlife species depends upon the requirements and characteristics of that species.

Hunting in the study area continues to be an extremely popular sport. Hunter use of game species is shown in Table 2.19.

Wildlife developments in the study area for the most part are restricted to watering facility construction and a minor amount of waterfowl habitat development. Most of the water fowl habitat development accomplished to date has been in the Willcox Playa.

Waterfowl habitat in the area is associated principally with multiple use lakes including Willcox Playa and Picacho Reservoir. See Table 2.7, page 2.40 and Table 4.7, page 4.15. There are also some irrigation tailwater and ponding areas which provide locally significant waterfowl habitat. An example of such conditions is in an area locally called "Lake of the Desert" northwest of Picacho Reservoir. These are basically Type 5 wetlands. 1/

Critical habitat is considered to be limited summering or wintering habitat for any one species or limited habitat necessary for the survival of a species. Wetland habitat is considered to be critical due to the limited extent of this habitat in the study area. Riparian habitat is also considered to be near critical for some species due to the current rate of net loss of this type. Orchards and landscaping vegetation do not substitute for displaced riparian habitat for those species less tolerant to man.

Endangered and Threatened Fish and Wildlife

The U.S. Fish and Wildlife Service has compiled four lists of fish and wildlife relating the rarity of those animals in the United States (36). Listings of fish and wildlife in the study area classified as "endangered," "threatened," "peripheral," and "status undetermined," are shown in Table 2.20.

An endangered species is one which is in danger of extinction throughout all or a significant portion of its range. A threatened species is one which is likely to become endangered within the foreseeable future throughout all or a significant portion of its range. A status undetermined species or sub-species is one which has been suggested as possibly threatened with extinction, but sufficient information to determine its status is not available. Peripheral refers to a species or sub-species whose occurrence in the United States is at the edge of its natural range and which is threatened with extinction in the United States, although not in its range as a whole.

1/ Classified in accordance with "Wetlands of the United States," Fish and Wildlife Service Circular 39.

TABLE 2.15

FISH

Santa Cruz-San Pedro

River Basins

Habitat Type	**Acres** (1,000)	Threadfin Shad (*Dorosoma petense*)	Rainbow Trout (*Salmo gairdneri*)	Carp (*Cyprinus carpio*)	Goldfish (*Carassius auratus*)	Colorado River Chub (*Gila robusta*)	Gila Chub (*Gila intermedia*)	Yaqui Chub (*Gila purpurea*)	Sonora Chub (*Gila ditaenia*)	Little Colorado River Spindace (*Lepidomeda uittata*)	Spikedace (*Meda fulgida*)	Longfin Dace (*Agosia chrysogaster*)	Speckled Dace (*Rhinichthys osculus*)	Loach Minnow (*Tiaroga cobitis*)	Yaqui Shiner (*Notropus formosus mearnsi*)
Riparian															
Pine-Mixed Conifer															
0-30% Canopy															
31-60% Canopy															
61-100% Canopy															
Oak-Woodland Chap.															
0-30% Canopy															
31-60% Canopy															
61-100% Canopy															
Desert															
Chihuahuan															
Sonoran															
Barren															
Grassland															
Cropland															
Urban Areas															
Existing															
Being Planned & Developed															
Mining Areas															
Ponds & Lakes		X	X	X	X										
Permanent Streams			X	X		X	X	X	X	X	X	X	X	X	X

TABLE 2.15

FISH

Santa Cruz-San Pedro

River Basins

Habitat Type	Acres (1,000)	Mexican Stoneroller (Campostoma ornatum pricei)	Fathead Minnow (Pimephales promelas)	Gila Mountain-Sucker (Pantosteus clarki)	Channel Catfish (Ictalurus punctatus)	Black Bullhead (Ictalurus melas)	Yellow Bullhead (Ictalurus natalis)	Desert Pupfish (Cyprinodon macularis)	Mosquitofish (Gambusia affinis)	Gila Topminnow (Poeciliopsis occidentalis)	Yaqui Topminnow (Poeciliopsis occidentalis sonorionsis)	Largemouth Minnow (Micropterus salmoides)	Green Sunfish (Chaenobryttus cyanellus)	Bluegill (Lepomis macrochirus)	Pumpkinseed (Lepomis gibbosus)
Riparian															
Pine-Mixed Conifer															
0-30% Canopy															
31-60% Canopy															
61-100% Canopy															
Oak-Woodland Chap.															
0-30% Canopy															
31-60% Canopy															
61-100% Canopy															
Desert															
Chihuahuan															
Sonoran															
Barren															
Grassland															
Cropland															
Urban Areas															
Existing															
Being Planned & Developed															
Mining Areas															
Ponds & Lakes			X	X	X	X	X		X			X	X	X	X
Permanent Streams		X	X		X			X	X	X	X	X			

TABLE 2.15

FISH

Santa Cruz-San Pedro

River Basins

Habitat Type	Acres (1,000)	Black Crappie (Promoxis nigromaculatus)	Mozambique Mouthbrooder (Tilapia mossambicia)												
Riparian															
Pine-Mixed Conifer 0-30% Canopy															
31-60% Canopy															
61-100% Canopy															
Oak-Woodland Chap. 0-30% Canopy															
31-60% Canopy															
61-100% Canopy															
Desert Chihuahuan															
Sonoran															
Barren															
Grassland															
Cropland															
Urban Areas Existing															
Being Planned															
& Developed															
Mining Areas															
Ponds & Lakes		X	X												
Permanent Streams															

Page 3 of 3 pages

TABLE 2.16

BIRDS

Santa Cruz-San Pedro

River Basins

Habitat Type	Acres	Eared Grebe (Podiceps caspicus)	Pied-Billed Grebe (Podilymbus podiceps)	Great Blue Heron (Ardea herodias)	Green Heron (Butorides virescens)	Yellow-Crowned Night Heron (Nyctanassa violacea)	Common Egret (Casmerodius albus)	Snowy Egret (Leucophoyx thula)	Least Bittern (Ixobrychus exilis)	American Bittern (Botaurus lentiginosus)	White-Faced Ibis (Plegadis chihi)	Canada Goose (Branta canadensis)	White-Fronted Goose (Anser albifrons)	Black-Bellied Tree Duck (Dendrocygna autumnalis)	Mallard (Anas platyrhynchos)
Riparian	77,921					X									
Pine-Mixed Conifer															
0-30% Canopy	46,595														
31-60% Canopy	74,891														
61-100% Canopy	9,088														
Oak-Woodland Chap.															
0-30% Canopy	993,844														
31-60% Canopy	588,098														
61-100% Canopy	36,807														
Desert															
Chihuahuan	613,261														
Sonoran	3,843,384														
Barren	108,490														
Grassland	3,093,172														
Cropland	646,782											X	X	X	
Urban Areas															
Existing	75,093														
Being Planned & Developed	311,599														
Mining Areas	41,407														
Ponds & Lakes		X	X	X	X		X	X	X	X	X	X	X	X	X
Permanent Streams					X		X	X							X

Page 1 of 18 pages

TABLE 2.16

BIRDS

Santa Cruz-San Pedro

River Basins

Habitat Type	Acres	Mexican Duck (Anas diazi)	Gadwall (Anas strepera)	Pintail (Anas acuta)	Green-Winged Teal (Anas Carolinensis)	Blue-Winged Teal (Anas discors)	Cinnamon Teal (Anas cyanoptera)	American Widgeon (Mareca americana)	Shoveler (Spatula clypeata)	Redhead (Aythya americana)	Ring-Necked Duck (Aythya collaris)	Canvasback (Aythya valisineria)	Lesser Scaup (Aythya affinis)	Bufflehead (Bucephala albeola)	Ruddy Duck (Oxyura jamaicensis)
Riparian	77,921														
Pine-Mixed Conifer															
0-30% Canopy	46,595														
31-60% Canopy	74,891														
61-100% Canopy	9,088														
Oak-Woodland Chap.															
0-30% Canopy	993,844														
31-60% Canopy	588,098														
61-100% Canopy	36,807														
Desert															
Chihuahuan	613,261														
Sonoran	3,843,384														
Barren	108,490														
Grassland	3,093,172														
Cropland	646,782			x											
Urban Areas															
Existing	75,093														
Being Planned & Developed	311,599														
Mining Areas	41,407														
Ponds & Lakes		x	x	x	x	x	x	x	x	x	x	x	x	x	x
Permanent Streams			x							x					

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TABLE 2.16

BIRDS

Santa Cruz-San Pedro

River Basins

Habitat Type	Acres	Common Merganser (Mergus merganser)	Red-Breasted Merganser (Mergus serrator)	Turkey Vulture (Cathartes aura)	Black Vulture (Coragyps atratus)	Goshawk (Accipiter gentilis)	Sharp-Shinned Hawk (Accipiter striatus)	Cooper's Hawk (Accipiter cooperii)	Red-Tailed Hawk (Buteo jamaicensis)	Swainson's Hawk (Buteo swainsoni)	Zone-Tailed Hawk (Buteo albonotatus)	White-Tailed Hawk (Buteo albicaudatus)	Rough-Legged Hawk (Buteo lagopus)	Ferruginous Hawk (Buteo regalis)	Gray Hawk (Buteo nitidus)
Riparian	77,921							X			X				X
Pine-Mixed Conifer				X		X	X								
0-30% Canopy	46,595														
31-60% Canopy	74,891					X	X								
61-100% Canopy	9,088														
Oak-Woodland Chap.				X				X	X						
0-30% Canopy	993,844														
31-60% Canopy	588,098														
61-100% Canopy	36,807														
Desert				X	X										
Chihuahuan	613,261														
Sonoran	3,843,384				X				X						
Barren	108,490				X										
Grassland	3,093,172			X	X				X	X		X	X	X	
Cropland	646,782			X	X										
Urban Areas				X											
Existing	75,093														
Being Planned & Developed	311,599														
Mining Areas	41,407														
Ponds & Lakes		X	X												
Permanent Streams															

TABLE 2.16

BIRDS

Santa Cruz-San Pedro

River Basins

Habitat Type	Acres	Harris' Hawk (Parabuteo unicinctus)	Black Hawk (Buteogallus anthracinus)	Golden Eagle (Aquila chrysaetos)	Bald Eagle (Haliaeetus leucocephalus)	Marsh Hawk (Circus cyaneus)	Osprey (Pandion haliaetus)	Caracara (Caracara cheriway)	Prairie Falcon (Falco mexicanus)	Peregrine Falcon (Falco peregrinus)	Aplomado Falcon (Falco femoralis)	Pigeon Hawk (Falco columbarius)	Sparrow Hawk (Falco sparverius)	Masked Bobwhite (Colinus virginianus ridgwayi)	Scaled Quail (Callipepla squamata)
Riparian	77,921	X	X				X	X							
Pine-Mixed Conifer															
0-30% Canopy	46,595			X											
31-60% Canopy	74,891			X											
61-100% Canopy	9,088														
Oak-Woodland Chap.															
0-30% Canopy	993,844					X							X		
31-60% Canopy	588,098														
61-100% Canopy	36,807														
Desert															
Chihuahuan	613,261														
Sonoran	3,843,384					X									
Barren	108,490														
Grassland	3,093,172					X			X	X	X	X	X	X	X
Cropland	646,782												X		
Urban Areas															
Existing	75,093												X		
Being Planned & Developed	311,599														
Mining Areas	41,407														
Ponds & Lakes					X		X								
Permanent Streams			X					X							

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TABLE 2.16

BIRDS

Santa Cruz-San Pedro

River Basins

Habitat Type	Acres	Gambel's Quail (Lophortyx gambelii)	Mearns' Quail (Cyrtonyx montezumae)	Ring-Necked Pheasant (Phasianus colchicus)	Turkey (Meleagris gallopavo)	Virginia Rail (Rallus limicola)	Sora (Porzana carolina)	Common Gallinule (Gallinula chloropus)	American Coot (Fulica americana)	Killdeer (Charadrius vociferus)	Mountain Plover (Eupoda montana)	Common Snipe (Capella gallinago)	Spotted Sandpiper (Actitis macularia)	Greater Yellowlegs (Totanus melanoleucus)	Least Sandpiper (Erolia minutilla)
Riparian	77,921	X													
Pine-Mixed Conifer			X		X										
0-30% Canopy	46,595														
31-60% Canopy	74,891		X												
61-100% Canopy	9,088														
Oak-Woodland Chap.		X	X												
0-30% Canopy	993,844														
31-60% Canopy	588,098		X												
61-100% Canopy	36,807														
Desert		X													
Chihuahuan	613,261														
Sonoran	3,843,384	X	X												
Barren	108,490	X									X				
Grassland	3,093,172	X									X				
Cropland	646,782			X						X					
Urban Areas															
Existing	75,093														
Being Planned & Developed	311,599														
Mining Areas	41,407														
Ponds & Lakes						X	X	X	X	X		X		X	
Permanent Streams								X				X	X		X

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TABLE 2.16

BIRDS

Santa Cruz-San Pedro

River Basins

Habitat Type	Acres	Black-Necked Stilt (Himantopus mexicanus)	Ring-Billed Gull (Larus delawarensis)	Band-Tailed Pigeon (Columba fasciata)	White-Winged Dove (Zenaida asiatica)	Mourning Dove (Zenaidura macroura)	Ground Dove (Columbigallina passerina)	Inca Dove (Scardafella inca)	Yellow-Billed Cuckoo (Coccyzus americanus)	Roadrunner (Geococcyx californianus)	Barn Owl (Tyto alba)	Screech Owl (Otus asio)	Great Horned Owl (Bubo virginianus)	Elf Owl (Micrathene whitneyi)	Burrowing Owl (Speotyto cunicularia)
Riparian	77,921				X	X	X					X		X	
Pine-Mixed Conifer 0-30% Canopy	46,595			X		X							X		
31-60% Canopy	74,891														
61-100% Canopy	9,088														
Oak-Woodland Chap. 0-30% Canopy	993,844			X	X	X						X	X	X	
31-60% Canopy	588,098			X								X			
61-100% Canopy	36,807														
Desert Chihuahuan	613,261				X	X				X	X	X			
Sonoran	3,843,384				X					X	X	X	X	X	X
Barren	108,490									X		X			
Grassland	3,093,172				X	X							X		X
Cropland	646,782				X	X	X	X							X
Urban Areas Existing	75,093				X	X	X	X							
Being Planned & Developed	311,599					X									
Mining Areas	41,407														
Ponds & Lakes		X	X												
Permanent Streams		X							X						

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TABLE 2.16

BIRDS

Santa Cruz-San Pedro

River Basins

Habitat Type	Acres	Long-Eared Owl (Asio otus)	Short-Eared Owl (Asio flammeus)	Saw-Whet Owl (Aegolius acadicus)	Whip-Poor-Will (Caprimulgus vociferus)	Poor-Will (Phalaenoptilus nuttallii)	Common Nighthawk (Chordeiles minor)	Broad-Tailed Hummingbird (Selasphorus platycercus)	Rivoli's Hummingbird (Eugenes fulgens)	Blue-Throated Hummingbird (Lampornis clemenciae)	Violet-Crowned Hummingbird (Amazilia verticalis)	Broad-Billed Hummingbird (Cynanthus latirostris)	Coppery-Tailed Trogon (Trogon elegans)	Belted Kingfisher (Megaceryle alcyon)	Green Kingfisher (Chloroceryle americana)
Riparian	77,921	X						X		X		X			
Pine-Mixed Conifer				X	X					X	X		X		
0-30% Canopy	46,595														
31-60% Canopy	74,891			X					X				X		
61-100% Canopy	9,088														
Oak-Woodland Chap.									X						
0-30% Canopy	993,844														
31-60% Canopy	588,098														
61-100% Canopy	36,807														
Desert			X												
Chihuahuan	613,261														
Sonoran	3,843,384				X	X	X	X	X			X			
Barren	108,490														
Grassland	3,093,172		X												
Cropland	646,782														
Urban Areas															
Existing	75,093														
Being Planned & Developed	311,599														
Mining Areas	41,407														
Ponds & Lakes														X	
Permanent Streams														X	X

TABLE 2.16

BIRDS

Santa Cruz-San Pedro

River Basins

Habitat Type	Acres	Red-Shafted Flicker (Colaptes cafer)	Gilded Flicker (Colaptes chrysoides)	Gila Woodpecker (Centurus uropygialis)	Acorn Woodpecker (Melanerpes formicivorus)	Lewis Woodpecker (Asyndesmus lewis)	Yellow-Bellied Sapsucker (Sphyrapicus varius)	Hairy Woodpecker (Dendrocopos villosus)	Ladder-Backed Woodpecker (Dendrocopos scalaris)	Arizona Woodpecker (Dendrocopos arizonae)	Rose-Throated Becard (Platypsaris aglaiae)	Thick-Billed Kingbird (Tyrannus crassirostris)	Tropical Kingbird (Tyrannus melancholicus)	Western Kingbird (Tyrannus verticalis)	Cassin's Kingbird (Tyrannus vociferans)
Riparian	77,921	X									X	X			X
Pine-Mixed Conifer						X				X				X	X
0-30% Canopy	46,595														
31-60% Canopy	74,891							X							
61-100% Canopy	9,088							X							
Oak-Woodland Chap.					X					X				X	X
0-30% Canopy	993,844														
31-60% Canopy	588,098														
61-100% Canopy	36,807														
Desert									X						
Chihuahuan	613,261														
Sonoran	3,843,384	X	X	X		X	X		X						X
Barren	108,490														
Grassland	3,093,172														
Cropland	646,782														
Urban Areas											X				
Existing	75,093														
Being Planned & Developed	311,599														
Mining Areas	41,407														
Ponds & Lakes															
Permanent Streams													X		

TABLE 2.16

BIRDS

Santa Cruz-San Pedro

River Basins

Habitat Type	Acres	Sulphur-Bellied Flycatcher (Myiodynastes luteiventris)	Ash-Throated Flycatcher (Myiarchus cinerascens)	Black Phoebe (Sayornis nigricans)	Say's Phoebe (Sayornis saya)	Traill's Flycatcher (Empidonax traillii)	Hammond's Flycatcher (Empidonax hammondii)	Dusky Flycatcher (Empidonax oberholseri)	Western Flycatcher (Empidonax difficilis)	Buff-Breasted Flycatcher (Empidonax fulvifrons)	Coues' Flycatcher (Contopus pertinax)	Western Wood Pewee (Contopus sordidulus)	Vermilion Flycatcher (Pyrocephalus rubinus)	Beardless Flycatcher (Camptostoma imberbe)	Horned Lark (Eremophila alpestris)
Riparian	77,921	x				x	x					x	x		
Pine-Mixed Conifer										x	x	x			
0-30% Canopy	46,595														
31-60% Canopy	74,891						x	x							
61-100% Canopy	9,088						x		x						
Oak-Woodland Chap.														x	
0-30% Canopy	993,844														
31-60% Canopy	588,098														
61-100% Canopy	36,807														
Desert								x							
Chihuahuan	613,261														
Sonoran	3,843,384		x		x						x				
Barren	108,490														
Grassland	3,093,172														x
Cropland	646,782														x
Urban Areas															
Existing	75,093														
Being Planned & Developed	311,599														
Mining Areas	41,407														
Ponds & Lakes															
Permanent Streams				x							x			x	

TABLE 2.16

BIRDS

Santa Cruz-San Pedro

River Basins

Habitat Type	Acres	Violet-Green Swallow (Tachycineta thalassina)	Tree Swallow (Iridoprocne bicolor)	Rough-Winged Swallow (Stelgidopteryx ruficollis)	Barn Swallow (Hirundo rustica)	Cliff Swallow (Petrochelidon pyrrhonota)	Purple Martin (Progne subis)	Steller's Jay (Cyanocitta stelleri)	Scrub Jay (Aphelocoma coerulescens)	Mexican Jay (Aphelocoma ultramarina)	Common Raven (Corvus corax)	White-Necked Raven (Corvus cryptoleucus)	Pinon Jay (Gymnorhinus cyanocephala)	Clark's Nutcracker (Nucifraga columbiana)	Mexican Chickadee (Parus sclateri)
Riparian	77,921				X		X								
Pine-Mixed Conifer															
0-30% Canopy	46,595	X											X		
31-60% Canopy	74,891	X						X						X	X
61-100% Canopy	9,088							X							
Oak-Woodland Chap.															
0-30% Canopy	993,844							X	X	X					
31-60% Canopy	588,098								X						
61-100% Canopy	36,807								X						
Desert															
Chihuahuan	613,261														
Sonoran	3,843,384						X		X			X			
Barren	108,490														
Grassland	3,093,172										X	X			
Cropland	646,782					X									
Urban Areas															
Existing	75,093				X	X									
Being Planned & Developed	311,599														
Mining Areas	41,407														
Ponds & Lakes			X	X		X									
Permanent Streams						X									

TABLE 2.16

BIRDS

Santa Cruz-San Pedro

River Basins

Habitat Type	Acres	Plain Titmouse (Parus inornatus)	Bridled Titmouse (Parus wollweberi)	Verdin (Auriparus flaviceps)	Common Bushtit (Psaltriparus minimus)	White-Breasted Nuthatch (Sitta carolinensis)	Red-Breasted Nuthatch (Sitta canadensis)	Pygmy Nuthatch (Sitta pygmaea)	Brown Creeper (Certhia familiaris)	Dipper (Cinclus mexicanus)	House Wren (Troglodytes aedon)	Brown-Throated Wren (Troglodytes brunneicollis)	Bewick's Wren (Thryomanes bewickii)	Cactus Wren (Campylorhynchus brunneicapillum)	Long-Billed Marsh Wren (Telmatodytes palustris)
Riparian	77,921					X									X
Pine-Mixed Conifer						X		X			X	X			
0-30% Canopy	46,595														
31-60% Canopy	74,891					X					X	X			
61-100% Canopy	9,088						X		X	X	X	X			
Oak-Woodland Chap.			X		X										
0-30% Canopy	993,844														
31-60% Canopy	588,098														
61-100% Canopy	36,807														
Desert				X										X	
Chihuahuan	613,261														
Sonoran	3,843,384	X	X	X	X								X	X	
Barren	108,490			X											
Grassland	3,093,172														
Cropland	646,782														
Urban Areas															
Existing	75,093														
Being Planned & Developed	311,599														
Mining Areas	41,407														
Ponds & Lakes															X
Permanent Streams										X					

TABLE 2.16

BIRDS

Santa Cruz-San Pedro

River Basins

Habitat Type	Acres	Canon Wren (Catherpes mexicanus)	Rock Wren (Salpinctes obsoletus)	Mockingbird (Mimus polyglottos)	Brown Thrasher (Toxostoma rufum)	Bendire's Thrasher (Toxostoma bendirei)	Curve-Billed Thrasher (Toxostoma curvirostre)	Crissal Thrasher (Toxostoma dorsale)	Sage Thrasher (Oreoscoptes montanus)	Robin (Turdus migratorius)	Hermit Thrush (Hylocichla guttata)	Swainson's Thrush (Hylocichla ustulata)	Eastern Bluebird (Sialia sialis)	Western Bluebird (Sialia mexicana)	Mountain Bluebird (Sialia currucoides)
Riparian	77,921			X						X					
Pine-Mixed Conifer 0-30% Canopy	46,595		X							X	X		X	X	X
31-60% Canopy	74,891		X								X				
61-100% Canopy	9,088		X							X	X	X			
Oak-Woodland Chap. 0-30% Canopy	993,844			X						X	X		X	X	X
31-60% Canopy	588,098										X				
61-100% Canopy	36,807														
Desert Chihuahuan	613,261			X					X						
Sonoran	3,843,172	X	X	X	X	X	X			X				X	X
Barren	108,490			X			X	X	X						
Grassland	3,093,172					X									
Cropland	646,782			X											
Urban Areas Existing	75,093			X			X								
Being Planned & Developed	311,599														
Mining Areas	41,407														
Ponds & Lakes															
Permanent Streams															

TABLE 2.16

BIRDS

Santa Cruz-San Pedro

River Basins

Habitat Type	Acres	Townsend's Solitaire (Myadestes townsendi)	Blue-Gray Gnatcatcher (Polioptila caerulea)	Black-T. Gnatcatcher (Polioptila melanura)	Golden-Crowned Kinglet (Regulus satrapa)	Ruby-Crowned Kinglet (Regulus calendula)	Water Pipit (Anthus spinoletta)	Sprague's Pipit (Anthus spragueii)	Cedar Waxwing (Bombycilla cedrorum)	Phainopepla (Phainopepla nitens)	Loggerhead Shrike (Lanius ludovicianus)	Starling (Sturnus vulgaris)	Hutton's Vireo (Vireo huttoni)	Gray Vireo (Vireo vicinior)	Solitary Vireo (Vireo solitarius)
Riparian	77,921														
Pine-Mixed Conifer															
0-30% Canopy	46,595														X
31-60% Canopy	74,891														
61-100% Canopy	9,088				X	X									
Oak-Woodland Chap.															
0-30% Canopy	993,844													X	
31-60% Canopy	588,098														
61-100% Canopy	36,807												X		
Desert															
Chihuahuan	613,261		X				X								
Sonoran	3,843,384	X							X	X	X	X			X
Barren	108,490			X											
Grassland	3,093,172							X							
Cropland	646,782						X	X				X			
Urban Areas															
Existing	75,093											X			
Being Planned & Developed	311,599														
Mining Areas	41,407														
Ponds & Lakes							X								
Permanent Streams							X								

TABLE 2.16

BIRDS

Santa Cruz-San Pedro

River Basins

Habitat Type	Acres	Warbling Vireo (Vireo gilvus)	Orange-Crowned Warbler (Vermivora celata)	Virginia's Warbler (Vermivora virginiae)	Lucy's Warbler (Vermivora luciae)	Olive Warbler (Peucedramus taeniatus)	Yellow Warbler (Dendroica petechia)	Myrtle Warbler (Dendroica coronata)	Audubon's Warbler (Dendroica auduboni)	Black-Th. Gray Warbler (Dendroica nigrescens)	Grace's Warbler (Dendroica graciae)	Yellowthroat (Geothlypis trichas)	Yellow-Breasted Chat (Icteria virens)	Red-Faced Warbler (Cardellina rubrifrons)	Painted Redstart (Setophaga picta)
Riparian	77,921						X		X						
Pine-Mixed Conifer															
0-30% Canopy	46,595	X				X				X	X			X	X
31-60% Canopy	74,891	X		X		X								X	
61-100% Canopy	9,088		X												
Oak-Woodland Chap.															
0-30% Canopy	993,844	X			X										X
31-60% Canopy	588,098									X					
61-100% Canopy	36,807														
Desert															
Chihuahuan	613,261														
Sonoran	3,843,384	X			X		X		X			X			
Barren	108,490							X							
Grassland	3,093,172											X			
Cropland	646,782							X				X			
Urban Areas															
Existing	75,093														
Being Planned & Developed	311,599														
Mining Areas	41,407														
Ponds & Lakes											X	X			
Permanent Streams							X					X			

TABLE 2.16

BIRDS

Santa Cruz-San Pedro

River Basins

Habitat Type	Acres	House Sparrow (Passer domesticus)	Eastern Meadowlark (Sturnella magna)	Western Meadowlark (Sturnella neglecta)	Yellow-Headed Blackbird (Xanthocephalus xanthocephalus)	Red-Winged Blackbird (Agelaius phoeniceus)	Hooded Oriole (Icterus cucullatus)	Scott's Oriole (Icterus parisorum)	Bullock's Oriole (Icterus bullockii)	Boat-Tailed Grackle (Cassidix mexicanus)	Brown-Headed Cowbird (Molothrus ater)	Bronzed Cowbird (Tangavius aeneus)	Western Tanager (Piranga ludoviciana)	Hepatic Tanager (Piranga flava)	Summer Tanager (Piranga rubra)
Riparian	77,921				X		X		X	X					
Pine-Mixed Conifer													X	X	X
0-30% Canopy	46,595														
31-60% Canopy	74,891												X		X
61-100% Canopy	9,088														
Oak-Woodland Chap.								X	X			X		X	
0-30% Canopy	993,844														
31-60% Canopy	588,098														
61-100% Canopy	36,807														
Desert															
Chihuahuan	613,261														
Sonoran	3,843,384					X	X				X				
Barren	108,490														X
Grassland	3,093,172		X	X											
Cropland	646,782	X	X	X	X	X			X			X			
Urban Areas		X					X		X	X	X				X
Existing	75,093														
Being Planned & Developed	311,599														
Mining Areas	41,407														
Ponds & Lakes															
Permanent Streams															

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BIRDS

Santa Cruz-San Pedro

River Basins

Habitat Type	Acres	Cardinal (Richmondena cardinalis)	Pyrrhuloxia (Pyrrhuloxia sinuata)	Black-Headed Grosbeak (Pheucticus melanocephalus)	Blue Grosbeak (Guiraca caerulea)	Lazuili Bunting (Passerina amoena)	Varied Bunting (Passerina versicolor)	Evening Grosbeak (Hesperiphona vespertina)	Cassin's Finch (Carpodacus cassinii)	House Finch (Carpodacus mexicanus)	Pine Grosbeak (Pinicola enucleator)	American Goldfinch (Spinus tristis)	Lesser Goldfinch (Spinus psaltria)	Red Crossbill (Loxia curvirostra)	Green-Tailed Towhee (Chlorura chlorura)
Riparian	77,921				X	X							X		
Pine-Mixed Conifer															
0-30% Canopy	46,595			X				X		X	X			X	
31-60% Canopy	74,891										X			X	
61-100% Canopy	9,088														
Oak-Woodland Chap.															
0-30% Canopy	993,844			X				X							
31-60% Canopy	588,098														
61-100% Canopy	36,807														
Desert															
Chihuahuan	613,261						X								X
Sonoran	3,843,384	X	X			X		X	X	X		X	X		X
Barren	108,490														
Grassland	3,093,172														
Cropland	646,782				X										
Urban Areas															
Existing	75,093									X					
Being Planned & Developed	311,599														
Mining Areas	41,407														
Ponds & Lakes															
Permanent Streams															

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BIRDS

Santa Cruz-San Pedro

River Basins

Habitat Type	Acres	Rufous-Sided Towhee (Pipilo erythrophthalmus)	Brown Towhee (Pipilo fuscus)	Albert's Towhee (Pipilo aberti)	Lark Bunting (Calamospiza melanocorys)	Savannah Sparrow (Passerculus sandwichensis)	Grasshopper Sparrow (Ammodramus savannarum)	Baird's Sparrow (Ammodramus bairdii)	Vesper Sparrow (Pooecetes gramineus)	Lark Sparrow (Chondestes grammacus)	Rufous-Winged Sparrow (Aimophila carpalis)	Rufous-Crowned Sparrow (Aimophila ruficeps)	Botteri's Sparrow (Aimophila botterii)	Cassin's Sparrow (Aimophila cassinii)	Black-Throated Sparrow (Amphispiza bilineata)
Riparian	77,921	X		X		X									
Pine-Mixed Conifer															
0-30% Canopy	46,595														
31-60% Canopy	74,891														
61-100% Canopy	9,088														
Oak-Woodland Chap.															
0-30% Canopy	993,844														
31-60% Canopy	588,098														
61-100% Canopy	36,807														
Desert															
'Chihuahuan	613,261			X		X					X				
Sonoran	3,843,384	X	X	X					X		X	X			
Barren	108,490				X										X
Grassland	3,093,172						X	X		X	X	X	X	X	
Cropland	646,782					X	X			X					
Urban Areas															
Existing	75,093														
Being Planned & Developed	311,599														
Mining Areas	41,407														
Ponds & Lakes															
Permanent Streams															

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BIRDS

Santa Cruz-San Pedro

River Basins

Habitat Type	Acres	Slate-Colored Junco (Junco hyemalis)	Oregon Junco (Junco oreganus)	Gray-Headed Junco (Junco caniceps)	Mexican Junco (Junco phaeonotus)	Chipping Sparrow (Spizella passerina)	Brewer's Sparrow (Spizella breweri)	Black-Chinned Sparrow (Spizella atrogularis)	White-Crowned Sparrow (Zonotrichia leucophrys)	White-Throated Sparrow (Zonotrichia albicollis)	Fox Sparrow (Passerella iliaca)	Lincoln's Sparrow (Melospiza lincolnii)	Song Sparrow (Melospiza melodia)	McCown's Longspur (Rhynchophanes mccownii)	Chestnut-Collared Longspur (Calcarius ornatus)
Riparian	77,921								X				X		
Pine-Mixed Conifer 0-30% Canopy	46,595		X	X	X								X		
31-60% Canopy	74,891			X	X										
61-100% Canopy	9,088				X										
Oak-Woodland Chap. 0-30% Canopy	993,844		X			X		X							
31-60% Canopy	588,098														
61-100% Canopy	36,807										X				
Desert Chihuahuan	613,261									X		X			
Sonoran	3,843,384		X			X	X	X	X						
Barren	108,490														
Grassland	3,093,172													X	X
Cropland	646,782	X				X			X			X	X		
Urban Areas Existing	75,093											X			
Being Planned & Developed	311,599														
Mining Areas	41,407														
Ponds & Lakes															
Permanent Streams													X		

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MAMMALS

Santa Cruz-San Pedro

River Basins

Habitat Type	Acres (1,000)	Vagrant Shrew (Sorex Vagrans)	Desert Shrew (Notiosorex crawfordii)	Peters' Leafchin Bat (Mormoops megalophylla)	California Leafnose Bat (Macrotus californicus)	Mexican Long-Tongued Bat (Choeronycteris)	Longnose Bat (Leptonycteris nivalis)	Yuma Myotis Bat (Myotis yumanensis)	Cave Myotis Bat (Myotis velifer)	Long-Eared Myotis Bat (Motis evotis)	Fringed Myotis Bat (Myotis thysanodes)	Long-Legged Myotis Bat (Myotis volans)	California Myotis Bat (Myotis californicus)	Small-Footed Myotis Bat (Myotis subulatus)	Silver-Haired Bat (Lasionycteris noctivagans)
Riparian	78														
Pine-Mixed Conifer															
0-30% Canopy	47	X				X	X		X	X	X	X	X	X	
31-60% Canopy	75	X								X	X	X	X	X	
61-100% Canopy	9	X								X					
Oak-Woodland Chap.															
0-30% Canopy	994		X		X	X	X	X	X	X			X	X	
31-60% Canopy	588		X	X		X	X	X	X	X	X	X	X	X	
61-100% Canopy	37		X			X	X		X	X	X	X	X	X	
Desert															
Chihuahuan	613		X		X		X						X		
Sonoran	3,843		X		X		X	X					X		X
Barren	108														
Grassland	3,093		X		X		X	X					X		X
Cropland	647		X												
Urban Areas															
Existing	75														
Being Planned & Developed	312														
Mining Areas	41														
Ponds & Lakes															
Permanent Streams															

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MAMMALS

Santa Cruz-San Pedro

River Basins

Habitat Type	Acres (1,000)	Western Pipistrelle (Pipistrellus hesperus)	Big Brown Bat (Eptesicus fuscus)	Red Bat (Lasiurus borealis)	Hoary Bat (Lasiurus cinereus)	Allen's Big-Eared Bat (Indionycteris phyllotis)	Townsend's Big-Eared Bat (Corynorhinus townsendii)	Pallid Bat (Antrozous pallidus)	Brazilian Freetail Bat (Tadarida brasiliensis)	Pocketed Freetail Bat (Tadarida femorosacca)	Big Freetail Bat (Tadarida molossa)	Greater Mastiff Bat (Eumops perotis)	Underwood's Mastiff Bat (Eumops underwoodi)	Antelope Jackrabbit (Lepus alleni)	Blacktail Jackrabbit (Lepus californicus)
Riparian	78			X				X	X						
Pine-Mixed Conifer															
0-30% Canopy	47	X	X	X	X	X	X	X	X						
31-60% Canopy	75	X	X	X	X	X		X	X						
61-100% Canopy	9			X	X	X		X	X		X				
Oak-Woodland Chap.															
0-30% Canopy	994	X					X	X	X		X			X	
31-60% Canopy	588	X	X				X	X	X		X				
61-100% Canopy	37	X	X			X	X	X	X						
Desert															
Chihuahuan	613	X	X					X	X	X	X	X		X	X
Sonoran	3,843	X	X					X	X	X	X	X	X	X	X
Barren	108														
Grassland	3,093							X	X	X	X	X		X	X
Cropland	647							X	X	X	X	X	X	X	X
Urban Areas															
Existing	75														
Being Planned & Developed	312														
Mining Areas	41														
Ponds & Lakes															
Permanent Streams															

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MAMMALS

Santa Cruz-San Pedro

River Basins

Habitat Type	Acres (1,000)	Eastern Cottontail Rabbit (Sylvilagus floridanus)	Desert Cottontail Rabbit (Sylvilagus audoboni)	Gunnisons Prarie Dog (Cynomys gunnisoni)	Spotted Ground Squirrel (Citellus spilosoma)	Rock Squirrel (Citellus variegatus)	Harris' Antelope Squirrel (Citellus harrisi)	Roundtail Ground Squirrel (Citellus tereticaudus)	Cliff Chipmunk (Eutamia dorsalis)	Aberts Squirrel (Sciuris Aberti)	Arizona Gray Squirrel (Sciuris arizonensis)	Apache Squirrel (Sciuris apache)	Graham Mountain Red Squirrel (Tamiasciurus hudsonicus)	Valley Pocket Gopher (Thomomys bottae)	Southern Pocket Gopher (Thomomys umbrinus)
Riparian	78	X				X								X	
Pine-Mixed Conifer 0-30% Canopy	47	X				X			X	X	X	X		X	
31-60% Canopy	75	X							X	X	X	X		X	
61-100% Canopy	9	X			X	X	X		X	X	X	X		X	X
Oak-Woodland Chap. 0-30% Canopy	994	X	X	X	X	X	X							X	X
31-60% Canopy	588	X	X		X	X	X					X		X	X
61-100% Canopy	37	X	X			X	X		X		X	X		X	X
Desert Chihuahuan	613	X	X		X	X	X							X	
Sonoran	3,843	X	X		X	X	X	X						X	X
Barren	108														
Grassland	3,093	X	X		X	X	X	X						X	X
Cropland	647	X	X											X	X
Urban Areas Existing	75														
Being Planned & Developed	312														
Mining Areas	41														
Ponds & Lakes															
Permanent Streams															

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MAMMALS

Santa Cruz-San Pedro

River Basins

Habitat Type	Acres (1,000)	Silky Pocket Mouse (Perognathus flavus)	Little Pocket Mouse (Perognathus longimembris)	Arizona Pocket Mouse (Perognathus amplus)	Hispid Pocket Mouse (Perognathus hispidus)	Bailey's Pocket Mouse (Perognathus baileyi)	Desert Pocket Mouse (Perognathus penicillatus)	Rock Pocket Mouse (Perognathus intermedius)	Bannertail Kangaroo Rat (Dipodomys spectabilis)	Merriams Kangaroo Rat (Dipodomys merriami)	Ords Kangaroo Rat (Dipodomys ordi)	Desert Kangaroo Rat (Dipodomys deserti)	Beaver (Castor canadensis)	Northern Grasshopper Mouse (Onychomys leucogaster)	Southern Grasshopper Mouse (Onychomys torridus)
Riparian	78												X		
Pine-Mixed Conifer															
0-30% Canopy	47														
31-60% Canopy	75														
61-100% Canopy	9														
Oak-Woodland Chap.															
0-30% Canopy	994	X													
31-60% Canopy	588	X													
61-100% Canopy	37	X													
Desert															
Chihuahuan	613				X		X		X	X	X			X	X
Sonoran	3,843	X	X	X	X	X	X	X	X	X	X	X		X	X
Barren	108														
Grassland	3,093		X	X	X	X	X	X	X	X	X	X		X	X
Cropland	647														
Urban Areas															
Existing	75														
Being Planned & Developed	312														
Mining Areas	41														
Ponds & Lakes													X		
Permanent Streams													X		

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MAMMALS

Santa Cruz-San Pedro

River Basins

Habitat Type	Acres (1,000)	Plains Harvest Mouse (Reithrodontomys montanus)	Western Harvest Mouse (Reithrogontomys megalotis)	Fulvous Harvest Mouse (Reithrodontomys fulvescens)	Northern Pygmy Mouse (Baiomys taylori)	Cactus Mouse (Peromyscus eremicus)	Merriams Mouse Peromyscus merriami)	Deer Mouse (Peromyscus maniculatus)	White-Footed Mouse (Peromyscus leucopus)	Brush Mouse (Peromyscus boylei)	Pinon Mouse (Peromyscus truei)	Rock Mouse (Peromyscus nasutus)	Hispid Cotton Rat (Sigmodon hispidus)	Least Cotton Rat (Sigmodon minimus)	Whitethroated Woodrat (Neotoma albigula)
Riparian	78						X								
Pine-Mixed Conifer 0-30% Canopy	47									X	X	X			
31-60% Canopy	75									X	X	X			
61-100% Canopy	9									X	X	X			
Oak-Woodland Chap. 0-30% Canopy	994		X		X					X			X		
31-60% Canopy	588		X							X	X	X			
61-100% Canopy	37									X	X	X			
Desert Chihuahuan	613	X	X	X	X	X		X	X				X	X	X
Sonoran	3,843	X	X	X		X	X	X	X				X	X	X
Barren	108														
Grassland	3,093	X	X	X	X	X	X	X	X				X	X	X
Cropland	647														
Urban Areas Existing	75														
Being Planned & Developed	312														
Mining Areas	41														
Ponds & Lakes															
Permanent Streams															

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MAMMALS

Santa Cruz-San Pedro

River Basins

Habitat Type	Acres (1,000)	Mexican Woodrat (Neotoma mexicana)	Longtail Vole (Microtus longicaudus)	Muskrat (Ondatra zibethicus)	Porcupine (Erethizon dorsatum)	Coyote (Canis latrans)	Gray Wolf (Canis lupus)	Kit Fox (Vulpes macrotis)	Gray Fox (Urocyon cinereoargenteus)	Black Bear (Euarctos americanus)	Ringtail (Bassariscus astutus)	Raccoon (Procyon lotor)	Coati (Nasua narica)	Longtail Weasel (Mustela frenata)	Badger (Taxidea taxus)
Riparian	78			X	X	X	X			X	X	X	X	X	X
Pine-Mixed Conifer															
0-30% Canopy	47	X	X		X	X	X		X	X	X	X	X	X	X
31-60% Canopy	75	X	X		X	X	X		X	X	X	X	X	X	X
61-100% Canopy	9		X		X	X	X			X	X	X	X	X	X
Oak-Woodland Chap.															
0-30% Canopy	994				X	X	X	X	X	X	X	X	X	X	X
31-60% Canopy	588	X			X	X	X		X	X	X	X	X	X	X
61-100% Canopy	37				X	X	X		X	X	X	X	X	X	X
Desert															
Chihuahuan	613					X	X	X	X		X	X		X	X
Sonoran	3,843					X		X			X	X			X
Barren	108														
Grassland	3,093					X		X	X						X
Cropland	647					X						X			X
Urban Areas															
Existing	75														
Being Planned & Developed	312														
Mining Areas	41														
Ponds & Lakes				X											
Permanent Streams				X											

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MAMMALS

Santa Cruz-San Pedro

River Basins

Habitat Type	Acres (1,000)	Spotted Skunk (Spilogale putorius)	Striped Skunk Mephitis mephitis)	Hooded Skunk (Mephitis macroura)	Hognose Skunk (Conepatus mesoleucus)	Jaguar (Felis onca)	Ocelot (Felis pardalis)	Mountain Lion (Felis concolor)	Bobcat (Lynx rufus)	(Javelina (Pecari tajacu)	Elk (Cervus canadensis)	Mule Deer (Odocoileus hemionus)	Whitetail Deer (Odocoileus virginianus)	Pronghorn Antelope (Antilocapra americana)	Bighorn Sheep (Ovis canadensis)
Riparian	78	X	X		X	X	X	X	X	X	X	X	X		
Pine-Mixed Conifer															
0-30% Canopy	47	X	X		X	X	X	X	X	X	X	X	X		X
31-60% Canopy	75	X	X		X	X	X	X	X	X	X	X	X		
61-100% Canopy	9	X	X		X	X	X	X	X		X	X	X		
Oak-Woodland Chap.															
0-30% Canopy	994	X	X	X	X			X	X	X		X	X		
31-60% Canopy	588	X	X	X	X			X	X	X		X	X		
61-100% Canopy	37	X	X	X	X		X	X	X	X		X	X		
Desert															
Chihuahuan	613	X	X	X	X				X	X		X	X	X	
Sonoran	3,843	X	X	X	X				X	X		X		X	X
Barren	108														
Grassland	3,093	X	X	X	X				X	X		X		X	
Cropland	647	X	X							X					
Urban Areas															
Existing	75														
Being Planned & Developed	312														
Mining Areas	41														
Ponds & Lakes															
Permanent Streams															

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TABLE 2.18

AMPHIBIANS AND REPTILES

Santa Cruz-San Pedro

River Basins

Habitat Type	Acres (1,000)	Couch's Spadefoot Toad (Scaphiopus couchi)	Plains Spadefoot Toad (Scaphiopus bombifrons)	Western Spadefoot Toad (Scaphiopus hammondi)	Barking Frog (Eleutherodactylus augusti)	Colorado River Toad (Bufo alvarius)	Southwestern Toad (Bufo microscaphus)	Canyon Treefrog (Hyla arenicolor)	Woodland Narrow-Mouthed Toad (Gastrophryne carolinensis)	Bullfrog (Rana catesbeiana)	Tarahumara Frog (Rana tarahumarae)	Sonoran Mud Turtle (Kinosternon sonoriense)	Western Box Turtle (Terrapene ornata)	Desert Tortoise (Gopherus agassizi)	Gila Monster (Heloderma suspectum)
Riparian	78					X	X	X			X				
Pine-Mixed Conifer				X.				X							
0-30% Canopy	47														
31-60% Canopy	75														
61-100% Canopy	9														
Oak-Woodland Chap.				X	X		X	X	X		X				
0-30% Canopy	994														
31-60% Canopy	588														
61-100% Canopy	37														
Desert				X			X	X				X		X	X
Chihuahuan	613														
Sonoran	3,843	X	X	X			X	X				X		X	X
Barren	108													X	
Grassland	3,093	X	X	X									X		
Cropland	647														
Urban Areas															
Existing	75														
Being Planned & Developed	312														
Mining Areas	41														
Ponds & Lakes										X					
Permanent Streams								X		X		X			

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TABLE 2.18

AMPHIBIANS AND REPTILES

Santa Cruz-San Pedro

River Basins

Habitat Type	Acres (1,000)	Desert Iguana (Dipsosaurus dorsalis)	Leopard Lizard (Gambelia wislizeni)	Chuckwalla (Savromalus obesus)	Madrean Earless Lizard (Holbrookia elegans)	Greater Earless Lizard (Holbrookia texana)	Zebra-Tailed Lizard (Callisaurus draconoides)	Bunch Grass Lizard (Sceloporus scalaris)	Mt. Spiny Lizard (Sceloporus jarrovi)	Eastern Fence Lizard (Sceloporus undulatus)	Striped Plateau Lizard (Sceloporus virgatus)	Sonora Spiny Lizard (Sceloporus clarki)	Desert Spiny Lizard (Sceloporus magister)	Long-Tailed Brush Lizard (Urosaurus graciosus)	Tree Lizard (Urosaurus ornatus)
Riparian	78											X			
Pine-Mixed Conifer															
0-30% Canopy	47							X	X	X	X				X
31-60% Canopy	75							X	X		X				
61-100% Canopy	9							X	X						
Oak-Woodland Chap.															
0-30% Canopy	994		X		X	X			X	X		X			X
31-60% Canopy	588		X												
61-100% Canopy	37		X												
Desert															
Chihuahuan	613	X	X	X			X							X	X
Sonoran	3,843		X		X	X				X		X	X		X
Barren	108		X				X							X	
Grassland	3,093		X										X		
Cropland	647														
Urban Areas															
Existing	75														
Being Planned & Developed	312														
Mining Areas	41														
Ponds & Lakes															
Permanent Streams															

TABLE 2.18

AMPHIBIANS AND REPTILES

Santa Cruz-San Pedro

River Basins

Habitat Type	Acres (1,000)	Side-Blotched Lizard (Uta stansburiana)	Round-Tailed Horned Lizard (Phrynosoma modestum)	Regal Horned Lizard (Phrynosoma solare)	Desert Horned Lizard (Phrynosoma platyrhinos)	Mountain Skink (Eumeces callicephalus)	Plains Skink (Eumeces obsoletus)	Sonora Whiptail (Cnemidophorus burti)	Spotted Whiptail (Cnemidophorus exsanguis)	Arizona Whiptail (Cnemidophorus arizonae)	Little Striped Whiptail (Cnemidophorus inornatus)	Western Whiptail (Cnemidophorus tigris)	Alligator Lizard (Gerrhonotus kingi)	Texas Blind Snake (Leptotyphlops dulcis)	Western Blind Snake (Leptotyphlops humilis)
Riparian	78							X					X		
Pine-Mixed Conifer															
0-30% Canopy	47					X	X		X				X		
31-60% Canopy	75														
61-100% Canopy	9														
Oak-Woodland Chap.															
0-30% Canopy	994					X	X		X	X		X	X	X	
31-60% Canopy	588														
61-100% Canopy	37														
Desert															
Chihuahuan	613	X			X					X		X			X
Sonoran	3,843	X	X	X								X	X		X
Barren	108	X			X			X							X
Grassland	3,093		X	X						X	X		X		X
Cropland	647														
Urban Areas															
Existing	75														
Being Planned & Developed	312														
Mining Areas	41														
Ponds & Lakes															
Permanent Streams															

TABLE 2.18

AMPHIBIANS AND REPTILES

Santa Cruz-San Pedro

River Basins

Habitat Type	Acres (1,000)	Mexican Garter Snake (Thamnophis egues)	Sonora Whiptail Snake (Masticophis bilineatus)	Mountain Patch-Nosed Snake (Salvadora grahamiae)	Desert Patch-Nosed Snake (Salvadora hexalepis)	Green Rat Snake (Elaphe triaspis)	Ringneck Snake (Diadophis punctatus)	Sonora Mountain Kingsnake (Lampropeltis pyromelana)	Saddled Leaf-Nosed Snake (Phyllorhynchus browni)	Spotted Leaf-Nosed Snake (Phyllorhynchus decurtatus)	Sonora Hooked-Nosed Snake (Ficimia guadrangularis)	Western Hooked-Nosed Snake (Ficimia cana)	Western Ground Snake (Sonora semiannulata)	Banded Burrowing Snake (Chilomeniscus cinctus)	Vine Snake (Oxybelis aeneus)
Riparian	78	X				X	X								X
Pine-Mixed Conifer				X				X							
0-30% Canopy	47														
31-60% Canopy	75							X							
61-100% Canopy	9														
Oak-Woodland Chap.		X	X	X	X	X	X	X							
0-30% Canopy	994														
31-60% Canopy	588														
61-100% Canopy	37														
Desert					X				X	X			X	X	
Chihuahuan	613														
Sonoran	3,843		X		X	X	X				X	X	X		X
Barren	108				X				X	X				X	
Grassland	3,093	X			X						X	X	X		
Cropland	647														
Urban Areas															
Existing	75														
Being Planned & Developed	312														
Mining Areas	41														
Ponds & Lakes															
Permanent Streams		X													

TABLE 2.18

AMPHIBIANS AND REPTILES

Santa Cruz-San Pedro

River Basins

Habitat Type	Acres (1,000)	Southwestern Lyre Snake (Trimorphodon lyrophanes)	Mexican Black-Headed Snake (Tantilla atriceps)	Huachuca Black-Headed Snake (Tantilla wilcoxi)	Arizona Coral Snake (Micruroides euryxanthus)	Black-Tailed Rattlesnake (Crotalus molossus)	Mohave Rattlesnake (Crotalus scutulatus)	Tiger Rattlesnake (Crotalus tigris)	Rock Rattlesnake (Crotalus lepidus)	Twin-Spotted Rattlesnake (Crotalus pricei)	Ridge-Nosed Rattlesnake (Crotalus willardi)	Sidewinder Rattlesnake (Crotalus cerastes)
Riparian	78	X										
Pine-Mixed Conifer						X			X	X		
0-30% Canopy	47											
31-60% Canopy	75									X		
61-100% Canopy	9									X		
Oak-Woodland Chap.		X		X	X	X			X	X	X	
0-30% Canopy	994											
31-60% Canopy	588											
61-100% Canopy	37											
Desert		X			X		X					X
Chihuahuan	613											
Sonoran	3,843	X	X		X	X	X	X			X	
Barren	108											X
Grassland	3,093	X	X		X		X					
Cropland	647											
Urban Areas												
Existing	75											
Being Planned & Developed	312											
Mining Areas	41											
Ponds & Lakes												
Permanent Streams												

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TABLE 2.19

HUNTER USE

SANTA CRUZ - SAN PEDRO RIVER BASINS

1970

(Taken from Game Survey Data, Arizona Game & Fish Department)

Species	Hunters Afield	Harvest
Whitewing dove	10,810	97,000
Mourning dove	15,730	975,690
Gambel's quail	15,330 1/	236,340
Scaled quail	--	36,150
Mearns quail	--	6,640
Tree squirrel 2/	360	730
Cottontail	9,720	88,050
Band-tailed pigeon	140	310
Turkey	375	20
Javelina	22,740	4,320
Mule deer	34,485 3/	2,710
Whitetail deer	--	1,520
Antelope	20	10
Bighorn sheep	42	15

1/ Total hunters afield for three species of quail
2/ Totals combined for four species of squirrel
3/ Total hunters afield for two species of deer

Source: Arizona Game and Fish Department, Arizona Small Game Investigations and Arizona Big Game Investigations, 1970-1971.

TABLE 2.20

ENDANGERED, THREATENED, STATUS UNDETERMINED, AND PERIPHERAL WILDLIFE
SANTA CRUZ - SAN PEDRO RIVER BASIN

Gila Topminnow - *(Poeciliopsis occidentalis occidentalis)*	Threatened
Mexican Stoneroller - *(Campostoma ornatum)*	Peripheral
Sonora Chub - *(Gila ditaenia)*	"
Yaqui Chub - *(Gila purpurea)*	Undetermined
Spikedace - *(Meda fulgida)*	"
Gila Monster - *(Heloderma suspectum)*	"
Arizona Ridge-Nosed Rattlesnake - *(Crotalus willardi willardi)*	"
Mexican Duck - *(Anas diazi)*	Endangered
Southern Bald Eagle - *(Haliaeetus leucocephalus)*	"
American Peregrine Falcon - *(Falco peregrinus anatum)*	"
Masked Bobwhite Quail - *(Colinus virginianus ridgwayi)*	"
Sonoran Pronghorn - *(Antilocapra americana sonoriensis)*	"
Mexican Wolf - *(Canis lupus baileyi)*	Threatened
Coatimundi - *(Nasua narica molaris)*	Peripheral
Jaguar - *(Felis onca veraecrucis)*	"
Arizona Prairie Dog - *(Cynomys ludovicianus)*	Undetermined
Chiricahua Squirrel - *(Sciurus nayaritensis chiricahuae)*	"
Black-Bellied Tree Duck - *(Dendrocygna autumnalis fulgens)*	Peripheral
Zone-tailed Hawk - *(Buteo albonotatus)*	"
Sennett's White-Tailed Hawk - *(Buteo albicaudatus hypospodius)*	"
Northern Gray Hawk - *(Buteo nitidus maximus)*	"
Northern Black Hawk - *(Buteogallus anthracinus)*	"
Northwestern Rose-Throated Becard - *(Platypsaris aglaiae richmodi)*	"
Northwestern Tropical Kingbird - *(Tyrannus melanchalieus occidentalis)*	"
Northern Thick-Billed Kingbird - *(Tyrannus crassirostris pompalis)*	"
Northern Buff-Breasted Flycatcher - *(Empidonax fulvifrons pygmaeus)*	"
Azure Eastern Bluebird - *(Sialia sialis fulva)*	"
Olive Warbler - *(Peucedramus taeniatus arizona)*	"
Dickey's Varied Bunting - *(Passerina versicolor dickeyae)*	"
Arizona Grasshopper Sparrow - *(Ammodramus savannarum)*	"
Northern Rufous-Winged Sparrow - *(Aimophila carpalis)*	"
Western Botteri's Sparrow - *(Aimophila botterii)*	"
Ferruginous Hawk - *(Buteo regalis)*	Undetermined
American Osprey - *(Pandion haliaetus carolinensis)*	"
Audubon's Caracara - *(Caracara cheriway audubonii)*	"
Northern Aplomado Falcon - *(Falco fermoalis septentrionalis)*	"
Prairie Pigeon Hawk - *(Falco columbarius richaedsonii)*	"
Mountain Plover - *(Eupoda montana)*	"
Violet Crowned Hummingbird - *(Amazilia verticalis)*	"
Blue-Throated Hummingbird - *(Lampornis clemenciae)*	"

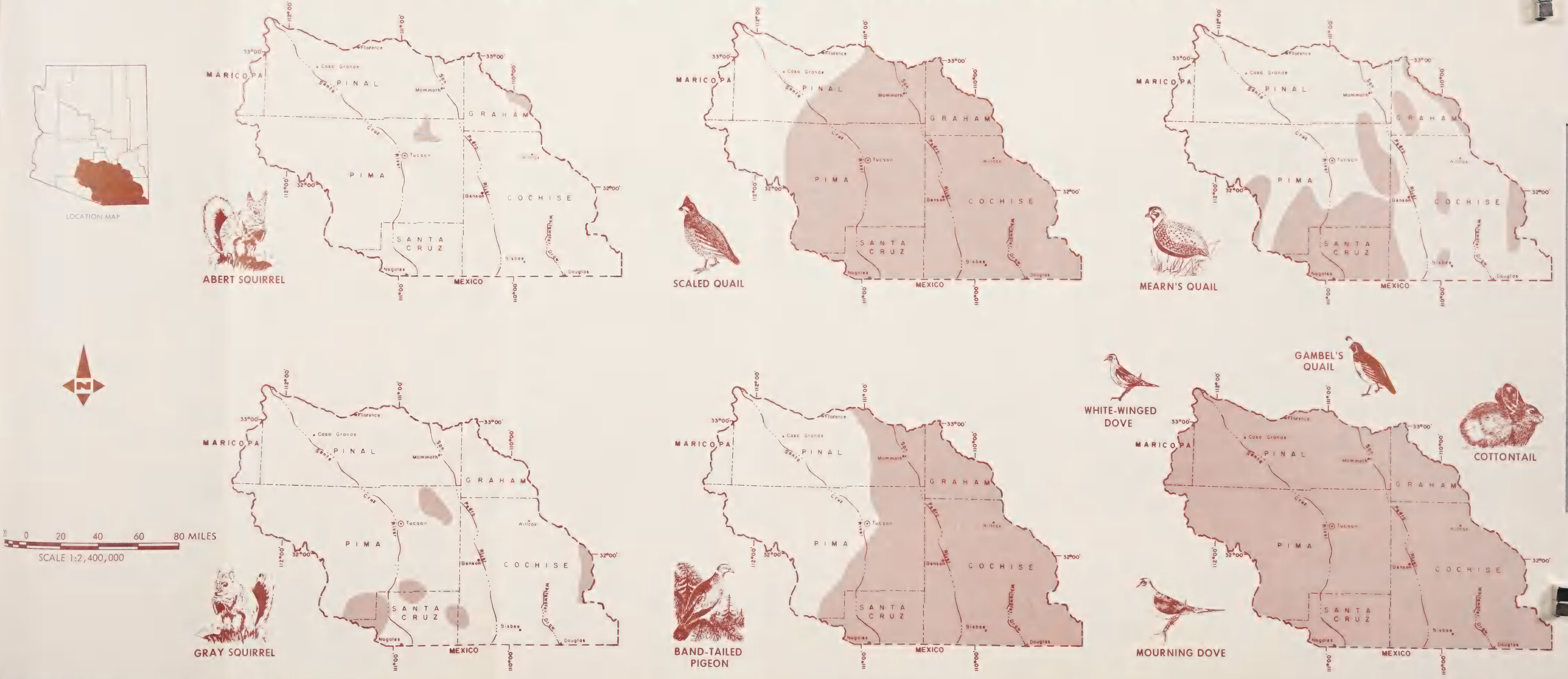
FIGURE 22

DISTRIBUTION OF BIG GAME, SANTA CRUZ - SAN PEDRO RIVER BASINS, ARIZONA

U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE USDA-SCS-PORTLAND, OR 1977

FIGURE 23

DISTRIBUTION OF SMALL GAME, SANTA CRUZ - SAN PEDRO RIVER BASINS, ARIZONA



NATURAL, UNIQUE GEOLOGICAL, AND AESTHETIC FEATURES

The topography, climate, and natural processes in the study area have resulted in the formation of many unique natural and geological features. These features are scenic and contribute to the aesthetics of the area. Many of these features are on lands administered by the Forest Service and the National Park Service. Table 2.21 exhibits outstanding scenic attractions, geologic features, and natural areas. Table 2.22 exhibits sites included in the National Registry of Natural Land Marks (37).

Aesthetic values of the study area include unique geological features, timber clad mountains, and the sparsely vegetated desert. Stands of riparian vegetation along drainageways and blocks of irrigated farmland serve as greenbelts adding variety and diversity to the desert landscape. The eroding badlands also add contrast to the areas which surround them.

ARCHEOLOGICAL AND HISTORICAL RESOURCES

Portions of the study area have been inhabited by humans for several thousand years. Indians were the only inhabitants until the sixteenth century when the Spanish exploration and mission activities began. In later centuries, the Mexicans and the Anglo-Americans played important roles in the history of the area. Tables 2.23 and 5.14 exhibit information about the places of importance relating to past human inhabitation and developments.

TABLE 2.21

OUTSTANDING SCENIC ATTRACTIONS, GEOLOGIC FEATURES, AND NATURAL AREAS IN THE SANTA CRUZ-SAN PEDRO RIVER BASINS

Name of Area	County	Description
Baboquivari Peak	Pima	A rugged mountain peak landmark located in a wilderness-type desert mountain range.
Colossal Cave	Pima	An ancient case known to prehistoric Indians located on the slopes of Rincon Mountains.
Madera Canyon	Pima	Scenic area famous for birdlife as many Mexican species just barely cross the border.
Mount Lemmon	Pima	A scenic 9,150 foot mountain.
Rose Canyon Lake	Pima	Natural area in Santa Catalina Mountains
Sabino Canyon	Pima	Cottonwoods and sycamores grow along stream in desert environment. Popular for nature study.
Saguaro National Monument	Pima	A dense forest of vigorous young saguaro cactus located in two sections, one located east of Tucson, the other west of Tucson.
Sawtooth Mountains	Pima & Pinal	Uniquely rugged, Sonoran Desert mountain range composed of a variety of volcanic rocks, including lava flows, tuffs, cinders, dikes plugs, and sills.
Aravaipa Canyon	Pinal	A deeply entrenched and colorful desert canyon with permanent stream, unique rock formations and unusual vegetation.
Crystal Cave	Pinal	Walls and roof of cave are gypsum interspersed with shale. Many beautiful crystals.
Picacho Peak	Pinal	An Arizona land mark visible for forty miles. The site of a Civil War confrontation between Confederate and Union troops.

TABLE 2.21 (Continued)

Name of Area	County	Descriptions
Pinal Pioneer Parkway	Pinal	A thirty mile stretch through a beautiful Sonoral Desert area.
Sierra Estrella	Pinal	Extremely rugged Sonoran Desert mountain range. Excellent example of fault block mountain.
Chiricahua Mountains	Cochise	An isolated mountain range in Coronado National Forest famous for its flora and fauna.
Chiricahua National Monument	Cochise	A series of tall, slender pinnacles, amazing stone likeness of giant beasts and men, grotesquely weird forms as though of another world carved by the erosive action of wind and water.
Cochise Stronghold	Cochise	The rugged mountain retreat of the famous Apache chief and his band of Indian raiders.
Coronado National Memorial	Cochise	A wilderness noted for its rich plant and animal life established to commemorate the entry of Coronado into the Arizona territory.
Ramsey Canyon	Cochise	A unique micro-climatic habitat.
Rucker Canyon	Cochise	Riparian area with prolific bird life.
San Pedro Valley	Cochise, Pima & Pinal	Excellent example of geologic erosion which has been accelerated by man's activities.
Texas Canyon	Cochise	Characterized by jumbled granitic rocks piles into unusual shapes. Colors vary from pink to deep amethyst, depending on time of day.
Volcanic field in San Bernardino Valley	Cochise	Good example of young cinder cones, calderas, craters, and lava flows.
Willcox Playa	Cochise	The largest and best-preserved playa in the southwest.

TABLE 2.21 (Continued)

Name of Area	County	Descriptions
Mount Graham	Graham	The phenomenon of a mountain rising from the desert floor to a height sufficient to support Alpine flora and fauna - 10,718 foot altitude.
Blue Haven	Santa Cruz	A stream flowing through tall trees in semi-desert hills. A back drop of high mountains adds to the beauty of this area.
Gardner Canyon	Santa Cruz	Natural area in Santa Rita Mountains
Parker Canyon	Santa Cruz	Natural area near Sunnyside
Patagonia Sonoita Creek	Santa Cruz	A unique and scenic area providing refuge for birds.

Source: Arizona Outdoor Recreation Coordinating Commission, State-wide Comprehensive Outdoor Recreation Plan, p. 151-153, (38) and Arizona State Parks Department.

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TABLE 2.22

SITES INCLUDED IN NATIONAL REGISTRY OF NATURAL LANDMARKS
SANTA CRUZ - SAN PEDRO RIVER BASINS

Name of Area	County	Location	Significance
Ramsey Canyon	Cochise	Seven miles south of Sierra Vista, Arizona	Unique micro-climatic habitat.
Willcox Playa	Cochise	Four miles south of Willcox	Largest dried up lake basin in Arizona - best preserved playa in the Southwest Region.
Patagonia-Sonoita Creek Sanctuary	Santa Cruz	Eleven miles northeast of Nogales	Unique bird refuge.

Source: U.S. Department of Interior, National Registry of Natural Landmarks, January, 1972.(37).

TABLE 2.23 PLACES OF ARCHEOLOGICAL OR HISTORICAL IMPORTANCE BY COUNTY AND LOCATION, SANTA CRUZ-SAN PEDRO RIVER BASINS

Name of Area	County	Location	Significance
Phelps Dodge General Office Building	Cochise	Bisbee, Copper Queen Plaza, intersection of Main Street and Brewery Gulch	Office building which also served as meeting place of a Masonic lodge and headquarters for community service agencies.
Coronado National Memorial	Cochise	30 miles southwest of Bisbee via Arizona 92 and secondary road	Memorial to the Spanish Explorer, Coronado, who was the first to extensively travel in the Arizona territory.
Lehner Mammoth-Kill Site	Cochise	10 miles west of Bisbee	Outstanding mammoth hunting sites in the new world.
Double Adobe Site	Cochise	12 miles northwest of Douglas on the west bank of White-water Creek	First site recognition of early and distinctive Cochise Culture.
San Bernardino Ranch	Cochise	7 miles east of Douglas on the international boundary	Outstanding example of the continuity of Spanish-Mexican-American ranching in the Southwest.
Garden Canyon Petroglyphs	Cochise	Sierra Vista, Garden Canyon Road	Petroglyphs are cut into the roof, approximately 10 feet high, of a small cave-like opening. Origin unknown.
Old Fort Huachuca	Cochise	3.56 miles west of Sierra Vista	Old Camp Huachuca, established in 1877, was used to protect the early settlers from Indian attack.

TABLE 2.23 Continued

Name of Area	County	Location	Significance
Quiburi	Cochise	North of Fairbank	Indian town where two parties of Father Kino's 1692 expedition met.
Stafford Cabin	Cochise	Southeast of Willcox	Pioneer cabin.
St. Paul's Episcopal Church	Cochise	Tombstone, Safford, and Third Streets	First church building in Tombstone. Completed in 1882.
Tombstone City Hall	Cochise	Tombstone, 315 East Fremont Street	Important architectural element.
Tombstone Courthouse (Cochise County Courthouse)	Cochise	Tombstone, 219 East Troughnut	County seat from 1881 to 1929.
Tombstone Historic District	Cochise	Tombstone	"The Town Too Tough To Die," the celebrated mining town on the Southwestern frontier is noted for among other things, Boothill grave yard, burial place of some of the West's most notorious characters, and the site of the Earp-Clanton showdown at the O.K. Corral.
Power's Cabin	Graham	Northwest of Willcox	Pioneer Cabin.
Sierra Bonita Ranch	Graham	Southwest of Bonita	First permanent American cattle ranch in Arizona.
Ventana Cave	Pima	11 miles west of Santa Rosa, Papago Indian Reservation	Relics and artifacts testify to human inhabitation for 4000 years.

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TABLE 2.23 Continued

Name of Area	County	Location	Significance
Cordova House	Pima	Tucson, 173-177 North Meyer Avenue	Possibly the oldest surviving structure in Tucson.
Empire Ranch	Pima	Southeast of Tucson	Ranch established in 1876.
Manning Cabin	Pima	East of Tucson	Pioneer cabin.
El Tiradito (Wishing Shrine)	Pima	Tucson, 221 South Main Street	This shrine is about 100 years old. A certain deceased individual is supposed to grant wishes to those who light votive candles for him.
Fremont House	Pima	Tucson, 145-153 South Main Street	Example of architecture that was common to the Tucson townscape around 1870.
The Old Abode Patio (Charles O. Brown House)	Pima	Tucson, 40 West Broadway	One of oldest territorial houses representing two distinct styles of adobe architecture common in Tucson.
Old Main	Pima	Tucson, University of Arizona Campus	The original University of Arizona Construction was completed in 1891.
Desert Laboratory	Pima	West Tucson off West Ankham Road	Carnegie Institute Establishment of Scientific Study, particularly concerned with the ecology of arid regions.
Velasco House	Pima	Tucson, 471-475-477 South Stone Avenue and 522 South Russel Street	Among other significances, it was the home of the first Spanish language newspaper, El Fronterizo.

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TABLE 2.23 Continued

Name of Area	County	Location	Significance
San Xavier del Bac	Pima	9 miles south of Tucson via Mission Road	One of the finest examples of Spanish Mission architecture in the Southwest, established by Padre Kino in 1700.
Casa Grande Ruins National Monument	Pinal	2 miles north of Coolidge on Arizona 87	The Casa Grande "Big House" was built by the Hohokam Indians about 800 years ago. Discovered by Spanish missionaries in 1694, the four-story apartment-watch tower was even then so ancient, the local tribes knew only legends of it.
C. H. Cook Memorial Church	Pinal	Sacaton	
First Florence Courthouse	Pinal	Florence, Fifth and Main Streets	First Pinal County Courthouse built in 1877-1878.
Adamville Ruin	Pinal	3.5 miles southwest of	Established during classic period of Hohokam
Calabasas	Santa Cruz	North of Nogales on the east bank of the Santa Cruz River	This site in the late 1600's served as a location for a Sobaipuri rancherio and later served as a location for a church, ranch, and various Mexican and American settlement and military activities.

TABLE 2.23 Continued

Name of Area	County	Location	Significance
Finley, James House	Santa Cruz	7.2 miles southwest of Patagonia on Harshaw Road in Coronado Forest	House occupied by various mining officials during mining boom.
Guevavi Mission Ruins	Santa Cruz	Nogales vicinity, approximately 6 miles above the international boundary	The first Spanish mission established in territory that became Arizona. Site was first visited in January 1691, by Father Kino.
Tumacacori National Monument	Santa Cruz	18 miles north of Nogales on Interstate 19	The mission of San Jose de Tumacacori was a northern outpost of the Sonoran Mission Chain founded by Jesuit Priests in the 17th Century.
Tubac Presidio	Santa Cruz	Tubac, Broadway and River Road	Spanish presidio and mission established in 1752.
Old Tubac Schoolhouse	Santa Cruz	Tubac, Broadway and River Road	Established about 1840, it is part of the historic heart of the village.
Pete Kitchen Ranch	Santa Cruz	7 miles north of Nogales	Established 1870.

Source: Federal Register, Vol. 40, No. 24, February 4, 1975, pp. 5250-5251, Arizona Recreation Plan, 1972 (39) and Arizona Place Names (40).

CHAPTER 3

SOCIO-ECONOMIC SITUATION (Base Period)

HISTORY

The Santa Cruz-San Pedro River Basins have been influenced by four cultures - Indian, Spanish, Mexican, and Anglo-American. The Indian ceremonial structure at Casa Grande Ruins National Monument, built about 1350, is a landmark of the Hohokam Indian culture that flourished 2,000 years ago. The Hohokam Indians lived in small scattered villages of single-roomed houses made of mud and brush. They carved shells and stone, made buff-colored pottery, gathered native plants for food, fiber, and shelter, and produced irrigated crops.

From the rich, colonial empire of Spain came the Spanish explorers and missionary priests. Fray Marcos de Niza's brief exploration of 1539 preceded Francisco Vasquez de Coronado's expedition of 1549. Historic documents indicate that this expedition included 300 Spanish soldiers, four priests, 800 Mexican-Indians, and a sizeable herd of sheep, horses, and cattle. The expedition traveled down the San Pedro River before crossing over into New Mexico. Compared to the passing influence of Spanish Conquistadors, the Jesuit missionaries such as Father Eusebio Francisco Kino, had more lasting influence on the Indians. Besides spreading Christianity, the missions served as a peaceful conquest as Indians were taught artisan skills, farming, and animal husbandry. The Mission of San Jose de Tumacacori was a frontier mission constructed by Franciscan priests in the late 1700's on a site previously established by Jesuit priests.

The mission served as the center of European culture and civilization in the area. The spread of missions was interrupted by raids of Apache Indians and the departure of the Spanish after 200 years of influence.

The period of Mexican influence was marked by unrest and rebellious rejection of the Spanish which resulted in Mexican independence from Spain in 1821. A number of Spanish land grants to Mexican and Spanish cattlemen were made between 1820 and 1826 at Canoa, San Rafael,Sonoita Creek, San Bernardino, Buena Vista, Boquillos and Babocomari. Except for a few rances along the Santa Cruz River, all of the estates were abandoned by 1846. At this time, Philip St. George Cooke of the Mormon Battalian reported encountering abandoned ranches, ruins of haciendas, and many wild cattle.

The impact of Anglo-Americans was largely one associated with migration to the West Coast before the Gadsden Purchase of 1853. The lands south of the Gila River were acquired from Mexico by the Gadsden Purchase, opening this area to settlement. Development of the Gadsden Purchase lands was interrupted by the Civil War (1861-65). With establishment of the Arizona Territory in 1863, homesteaders began to move into the San Pedro Valley and were given increasing protection from the Apaches by the Army.

Beginning with the Butterfield stages of the pioneer period, the transportation of people, resources, and products has progressed through the arrival of transcontinental railroads of the 1880's and the gradual development of giant diesel motorized trucks and buses to the ultimate inception of transcontinental jet aircraft.

Numerous mining communities became established after the 1880's. Some were abandoned and became true ghost towns. Others, such as Tombstone, survived and are inhabited today. The 1880's were also identified with the rapid expansion of ranching. Deterioration of ranges by overgrazing came under natural climatic control when the drought of 1891-1892 resulting in staggering death losses of cattle in 1893.

LAND OWNERSHIP AND ADMINISTRATION

The lands within the Santa Cruz-San Pedro River Basin were obtained by the United States from Mexico through the Gadsden Purchase in 1853. The Spanish land grants within the area were recognized by the United States Government as private lands; and all other lands became a part of the Nation's public domain. Withdrawals from the public domain for national parks, national forests, and other purposes have created the current patterns of land ownership and administration.

By 1970, about 32 percent of the study area had come into individual or corporate ownership, 14 percent was Indian trust land, 32 percent was state trust land, and 22 percent remained under federal control (Figure 24).

(Basic land ownership and administration statistics are presented in Table 3.1. Location is shown on the Land Ownership and Administration Map).

Federal Land

Land in the Federal system is administered by the Forest Service of the Department of Agriculture (USDA), by the Bureau of Land Management, the National Park Service of the Department of the Interior (USDI), and by the Department of Defense.

Forest Service

The Forest Service administers the land reserved as the national forest system for many purposes including recreation, forage, timber, water, research, and wildlife. The Chiricahua Wilderness and the Galiuro Wilderness are areas set aside for the preservation of primitive or natural conditions.

The Landownership and Administration Map exhibits various plots of land within national forest boundaries which are private, state or other

TABLE 3.1

LAND OWNERSHIP AND ADMINISTRATION BY COUNTY,
Santa Cruz-San Pedro River Basin, 1972

OWNERSHIP AND/OR ADMINISTRA.	COUNTY						
	Cochise	Graham	Maricopa	Pima	Pinal	Santa Cruz	TOTAL
Federal Land							
Forest Service (Acres)	339,048	223,574	0	357,470	23,411	376,052	1,319,555
% of County	10.84	34.70	0	10.85	0.92	50.49	-
% of Total FS	25.70	16.94	0	27.09	1.77	28.50	100
Bur. of Land Mgmt. (Acres)	129,110	23,660	67,940	169,421	330,714	1,680	722,525
% of County	4.13	3.68	35.07	5.13	12.96	0.23	-
% of Total BLM	17.87	3.28	9.40	23.45	45.77	.23	100
Nat'l. Park Service (Acres)	14,265	0	0	76,128	472	10	90,875
% of County	0.46	0	0	2.31	0.02	-	-
% of Total NPS	15.70	0	0	83.77	.52	0.01	100
Dept. of Defense (Acres)	107,779	0	43,140	18,177	0	0	169,096
% of County	3.44	0	22.27	0.55	0	0	-
% of Total Defense	63.74	0	25.51	10.75	0	0	100
Federal by Others (Acres)	0	0	0	7,880	0	0	7,880
% of County	0	0	0	0.24	0	0	-
% of Total Others	0	0	0	100.00	0	0	100
Total Federal (Acres)	(590,202)	(247,234)	(111,080)	(629,076)	(354,597)	(377,742)	(2,309,931)
% of County	(18.87)	(38.38)	(57.34)	(19.08)	(13.89)	(50.72)	-
% of Total Federal	25.55	10.70	4.81	27.24	15.35	16.35	100
Private Land (Acres)	1,406,285	136,467	15,920	808,077	706,706	304,939	3,378,394
% of County	44.94	21.18	8.22	24.52	27.69	40.94	-
% of Total Private	41.62	4.04	0.47	23.92	20.92	9.03	100
Indian Trust	0	0	63,840	926,233	479,026	0	1,469,099
% of County	0	0	32.96	28.10	18.77	0	-
% of Total Indian Tr.	0	0	4.34	63.05	32.61	0	100

TABLE 3.1 (Continued)

OWNERSHIP AND/OR ADMINISTRA	COUNTY						
	Cochise	Graham	Maricopa	Pima	Pinal	Santa Cruz	Total
State of Arizona							
State Land Dept. (acres)	1,127,986	260,400	2,860	924,926	1,003,960	62,083	3,382,215
% of County	36.05	40.42	1.48	28,06	39.33	8.34	-
% of Total SLD	33.35	7.70	.08	27.35	29.68	1.84	100
Other State Agencies (acres)	1,080	160	0	1,536	5,122	5	7,903
% of County	0.03	0.02	0	0.05	.20	-	-
% of Total O. St.	13.66	0.00	0	19.43	64.81	-	100
Total State (acres)	(1,129,066)	(260,560)	(2,860)	(926,462)	(1,009,082)	(62,088)	(3,390,118)
% of County	(36.08)	(40.44	(1.48)	(28.11)	(39.53)	(8.34)	-
% of Total Ariz.	33.30	7.69	0.08	27.33	29.77	1.83	100
County & Municipal (acres)	3,440	0	0	6,320	3,130	0	12,890
% of County	0.11	0	0	0.19	0.12	0	-
% of Total C&M	26.69	0	0	49.03	24.28	0	100
Total Basin (acres)	3,128,993	664,261	193,700	3,296,168	2,552,541	744,769	10,560,432
% of Total RB	29.63	6.10	1.84	31.21	24.17	7.05	100

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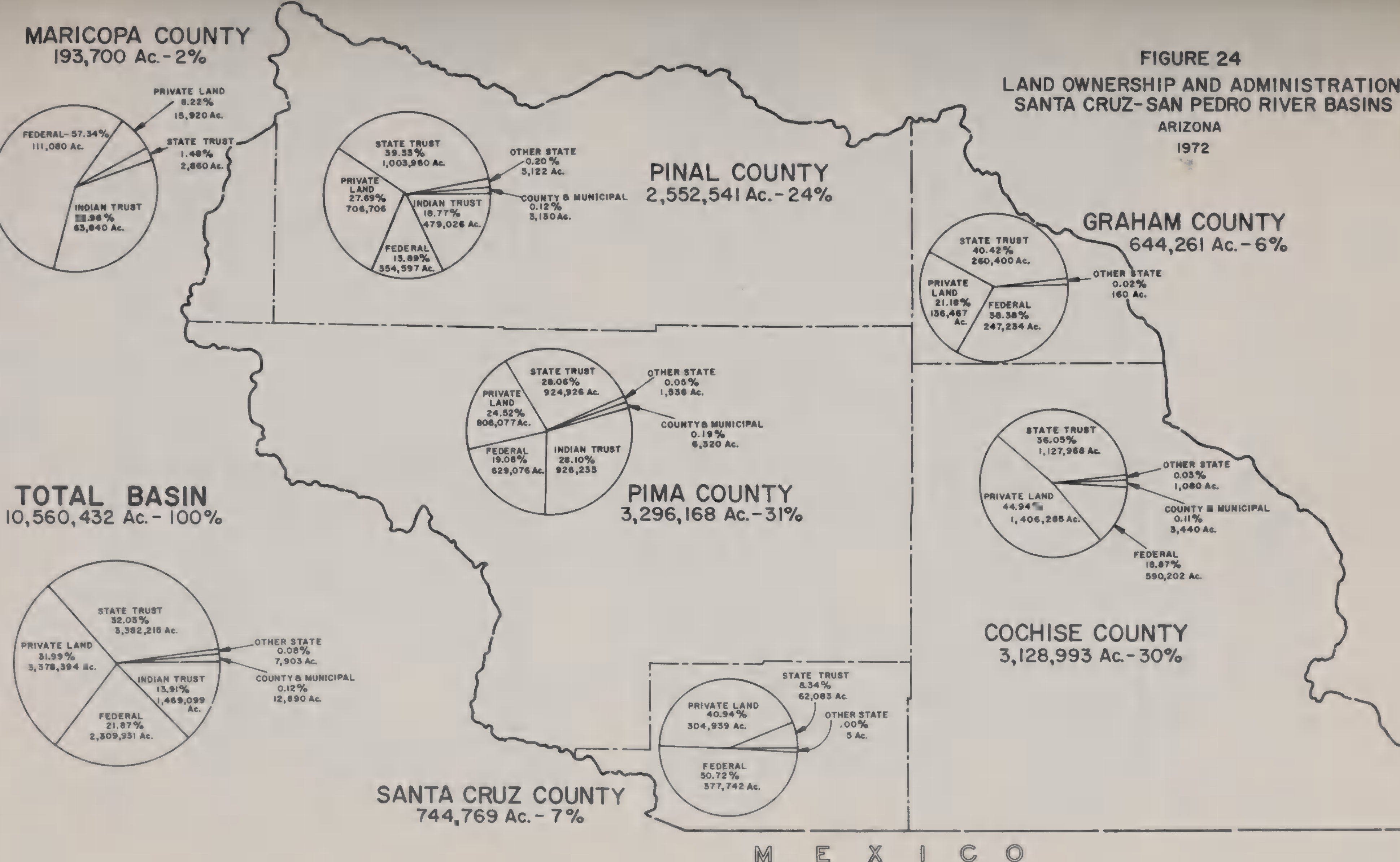

FIGURE 24
LAND OWNERSHIP AND ADMINISTRATION
SANTA CRUZ-SAN PEDRO RIVER BASINS
ARIZONA
1972

non-federal lands. These lands, consisting of 118,647 acres, include farms or ranches, small communities or towns, state or local parks, recreation areas, and public reservoirs. This acreage is included in the land in private ownership.

Bureau of Land Management

The Bureau of Land Management (BLM) currently administers about three quarters of a million acres or about seven percent of the study area. Over 45 percent of the BLM land is located in Pinal County.

The Classification and Multiple Use Act of 1964 directed the Secretary of the Interior to determine which of the public lands administered by BLM should be classified as suitable for disposal or retention for multiple-use management. Lands classified for disposal can be transferred to states, counties, municipalities, and private interests to meet their specific needs. Special-use arrangements or uses not presently covered by existing public land laws can be made by private individuals or concerns for the use of public lands.

National Park Service

The National Park Service administers nearly 91,000 acres of national park lands located in the study area. A major portion of this land is in the Saguaro National Monument located near Tucson in Pima County. Other monuments and memorials in the study area include the Casa Grande Ruins in Pinal County, the Tumacacori National Monument in Santa Cruz County, and the Chiricahua National Monument, and Coronado National Monument in Cochise County.

Department of Defense

The Department of Defense administers wholly or in part 169,096 acres. Generally, lands withdrawn for military purposes are managed by the Department of Defense for a single-purpose use. However, some of these lands support grazing, recreation, and other uses that do not interfere with military uses.

Others

Federal land administered by others consists of 7,880 acres in Pima County. This land is part of the Tucson Mountain County Park and is administered by the county.

Private Land

Individual or corporate lands have been obtained from public domain under various land laws. Together with the original Spanish land grants they include about 32 percent of the study area or 3,378,394 acres.

Railroad land grant laws passed in the early 1850's encouraged the building of railroads in vacant and sparsely settled portions of the

country. These grants resulted in a shift of large acreages from federal to private ownership. The railroads sold this land to individuals, corporations, and municipalities.

Through the passage of various homestead acts and the Desert Land Act of 1887, other large blocks of public domain lands have been transferred from federal to private ownership. Under these laws, it was possible for a citizen of the United States over 21 years of age to acquire land at a very low cost by settling and developing it. The Desert Land Act allowed an individual to acquire 640 acres of land at 25 cents an acre. provided the land became irrigated within three years.

(The result of these acts and laws can be seen through analysis of the Land Ownership and Administration Map).

Large blocks of private lands are located along the Santa Cruz River in Pima, Pinal, and Santa Cruz Counties; in the southern portion of the San Pedro River Valley; and in the Sulphur Springs Valley between Willcox and Douglas in Cochise County.

A small amount of land is still being disposed of today for specific purposes under appropriate laws, but it is difficult to find land that will meet the requirements of the present-day land laws. Some public domain is being sold or exchanged to private and non-federal public interests when the best interest of the public is served. Except for small subdivision plots sold to urban dwellers, most of the private lands are considered agricultural. Individual and corporate ownership of agricultural units ranges from 10 acres to over 100,000 acres. The number and size of farm operating units by county and by economic class is discussed in later sections of this chapter.

Indian Trust Lands

The Bureau of Indian Affairs holds in trust for the Indian tribes the title to reservation lands. The United States also holds in trust title to lands allotted to ownership by individual tribal members or their heirs. As trustee, the Federal Government is responsible for the protection and management of these lands. Indian trust lands include 1,469,099 acres or 14 percent of the total study area.

State Of Arizona

The total state-owned land in the study area amounts to over three million acres. A large share of state-owned land resulted from land grants for aid to education. The school land grants were set aside at statehood, but the title did not pass until the lands were surveyed. Arizona was granted four sections of public domain land per township for aid to public schools. In addition, Arizona was granted land to support penitentiaries, military institutes, payment of bonds, and similar purposes.

State Land Department

The State Land Department administers 99.8 percent of the state land. The State Land Commissioner, as executive officer of the Land Department, interprets and administers all laws pertaining to these lands.

Other

Other state agencies manage the state lands not administered by the State Land Department. The State Department of Transportation is responsible for state highway rights-of-way. The Arizona State Prison located in Florence, and Fort Grant, located just north of Bonita in Graham County, are administered by the Arizona Department of Correction. The University of Arizona at Tucson and Central Arizona College, a small community college located between Casa Grande and Coolidge, have their own governing boards.

Lands administered by the Arizona State Parks Board are Picacho Peak, Tubac Presidio, Tombstone Courthouse, Florence Courthouse, and Patagonia Lake state parks. The total state land administered by state agencies outside the State Land Department amounts to 8,548 acres.

County and Municipal

The various towns and cities within the study area own and administer 12,890 acres. These acreages occur in the form of parks, airports, and other public facilities.

POPULATION CHARACTERISTICS

From the standpoint of social factors, the study area was defined on a county basis to consist of Cochise, Pima, Pinal, and Santa Cruz Counties since it is not feasible to derive such data on a hydrologic basis.

Based on the four-county area statistics, the population of the study area in 1970 totalled 495,500 (see Table 3.2). The major part of the population - 71 percent - was in Pima County. About 14 percent was in Pinal County, 12 percent in Cochise County, and 3 percent in Santa Cruz County.

Population of the four-county area more than doubled in the 20-year period from 1950 to 1970, a growth rate nearly as rapid as that of Arizona and more than double the rate for the United States. The most rapid growth occurred in Pima County, where the 1970 population was 2.5 times that in 1950. In Cochise County, the population nearly doubled over the 20-year period; while in Pinal and Santa Cruz Counties, the 1950 population was 67 and 64 percent, respectively, of 1970. With Pima and Pinal Counties combined, the 1950 population was 44 percent of 1970 population compared with 54 percent for Cochise and Santa Cruz Counties combined.

TABLE 3-2
POPULATION, 1970 AND HISTORICAL TRENDS,
SANTA CRUZ-SAN PEDRO 4-COUNTY AREA 1/

Area	1950	1960	1970	1950-60	1960-70
	-------------1000-------------			-----Increase----	
Cochise County	31.5	55.0	61.9	74.6	12.5
Santa Cruz County	9.3	10.8	14.0	16.1	29.6
2-County Total	40.8	65.8	75.9	61.3	15.3
Pima County	141.2	265.7	351.7	88.2	32.4
Pinal County	43.2	62.7	67.9	45.1	8.3
2-County Total	184.4	328.4	419.6	78.1	27.8
4-County Total	225.2	394.2	495.5	75.0	25.7
Arizona	750.0	1302.2	1770.9	73.7	36.0
United States	151325.8	179322.2	203211.9	18.5	13.3
	-------Percent-1970=100-------				
Cochise	50.9	88.9	100		
Santa Cruz	66.9	77.4	100		
2-County Total	53.8	86.7	100		
Pima	40.2	75.5	100		
Pinal	63.6	92.3	100		
2-County Total	43.9	78.3	100		
4-County Total	45.5	79.6	100		
Arizona	42.7	73.5	100		
United States	74.7	88.3	100		

1/ Source: U.S. Census; U.S., Statistical Abstract of the U.S. 1972, p.5.

The rate of population increase in the four-county area from 1960 to 1970 was only about one-third the rate in the 1950's. Only Santa Cruz County showed a faster rate of growth in the latter decade. The rate of increase in the four-county area in the 1950's was slightly above that in Arizona and four times that in the United States. During the 1960's, the area's population grew slower than in Arizona; but it was nearly twice the rate for the United States.

The major part of the population of the four-county area was classified as "urban" or "rural nonfarm" in 1970. Only 2.7 percent was classified as farm population (see Table 3.3). This low percentage is due in part to the concentration of Pima County population in Tucson. The farm population in Cochise and Santa Cruz Counties comprised about 9.0 percent.

Population growth in the four-county area occurred primarily in the cities and somewhat in the rural nonfarm group, while the farm population generally declined. Farm population declined sharply in all four counties from 1950 to 1960, and it continued to decline from 1960 to 1970 in all except Pima County. The proportion of the population classified as "urban" increased substantially from 1950 to 1970, and the "rural nonfarm" proportion declined somewhat.

EMPLOYMENT, INCOME, AND EARNINGS

Total employment in the Santa Cruz-San Pedro four-county area in 1969 was 178,700 (see Table 3.4). This was two and one-half times the number in 1950 and 34 percent above the number employed in 1959. Employment increased at a faster rate than the population over these two decades. In 1969, the employment/population ratio was .36 compared with .32 in 1950.

Per capita income, in 1967 dollars, averaged $2,930 in the four-county area in 1969, an increase of 57 percent from the 1950 level (see Table 3.4). It averaged 90 percent of the United States average in 1950 and increased to 92 percent in 1959. However, during the 1960's, the rate of per capita income growth was lower in the four-county area than for the Nation, with the result that the relative level dropped to .86 in 1969.

Earnings per worker, also in 1967 dollars, averages $6,287 in 1969, and increase of 31 percent from the 1950 level. It is noteworthy that the 1950 level was above the United States average. However, in 1969, earnings of the average worker in the four-county area were only 92 percent of the United States average.

Total personal income, total earnings, and total earnings by sector for the four-county area are shown in 1967 dollars in Table 3.5. Total personal income was 1.4 billion in 1967 dollars in 1969, a 3.4-fold increase from 1950. Total earnings in 1969 were 1.1 billion in 1967 dollars, a 3.3-fold increase from 1950.

TABLE 3.3
POPULATION CLASSIFIED URBAN AND RURAL, 1970 AND HISTORICAL TRENDS, SANTA CRUZ-SAN PEDRO 4-COUNTY AREA 1/

Area and Residence	Number-Thousands 1950	1960	1970	Percent 1950	1960	1970
Cochise County						
Urban	15.9	24.9	39.9	50.4	45.3	64.4
Rural nonfarm	12.2	27.5	19.6	38.6	50.0	31.7
Rural farm	3.5	2.6	2.4	11.0	4.7	3.9
Total	31.5	55.0	61.9	100.0	100.0	100.0
Santa Cruz County						
Urban	6.1	7.3	8.9	65.7	67.4	63.9
Rural nonfarm	2.2	2.8	4.4	24.0	26.1	31.7
Rural farm	1.0	.7	.6	10.3	6.5	4.4
Total	9.3	10.8	14.0	100.0	100.0	100.0
2-County Total 2/						
Urban	22.0	32.2	48.8	53.8	48.9	64.4
Rural nonfarm	14.4	30.3	24.0	35.2	46.1	31.7
Rural farm	4.5	3.3	3.0	11.0	5.0	3.9
Total	40.8	65.8	75.9	100.0	100.0	100.0
Pima County						
Urban	78.3	234.5	299.9	55.3	88.3	85.3
Rural nonfarm	55.5	28.4	47.7	39.4	10.7	13.6
Rural farm	7.4	2.8	4.0	5.3	1.0	1.1
Total	141.2	265.7	351.7	100.0	100.0	100.0
Pinal County						
Urban	12.1	27.6	32.5	28.0	44.1	47.9
Rural nonfarm	18.0	28.1	29.3	41.6	44.8	43.1
Rural farm	13.1	7.0	6.1	30.4	11.1	9.0
Total	43.2	62.7	67.9	100.0	100.0	100.0
2-County Total 2/						
Urban	90.4	262.1	332.4	49.0	79.8	79.2
Rural nonfarm	73.5	56.5	77.0	39.9	17.2	18.4
Rural Farm	20.5	9.8	10.1	11.1	3.0	2.4
Total	184.4	328.4	419.6	100.0	100.0	100.0
4-County Total 2/						
Urban	112.4	294.3	381.2	49.9	74.7	76.9
Rural nonfarm	87.9	86.8	101.0	39.0	22.0	20.4
Rural farm	25.0	13.1	13.2	11.1	3.3	2.7
Total	225.2	394.2	495.5	100.0	100.0	100.0

1/ Source: U.S. Census. Items may not add to total due to rounding.
2/ County figures may not add to totals due to rounding.

TABLE 3.4
EMPLOYMENT AND PER CAPITA INCOME AND EARNINGS PER WORKER, 1950-1969,
SANTA CRUZ-SAN PEDRO 4-COUNTY AREA

Item	Unit	1950	1959	1969
Total Employment	1000	71.7	133.2	178.7
Employment/Population	Ratio	.32	.35	.36
Per Capita Income	1967$	1868	2255	2930
Per Capita Inc. Relative	US = 1.00	.90	.92	.86
Earnings Per Worker	1967$	4787	5317	6287
Earnings Per Worker Rel.	US = 1.00	1.06	.99	.92
		--------Percent-1969=100--------		
Total Employment		40.1	74.5	100
Per Capita Income		63.8	77.0	100
Earnings Per Worker		76.1	84.6	100

Source: 1972 OBERS Projections, Vol., 4, p. 213.

Agriculture was the only sector for which data are available that showed a decline in total earnings in 1967 dollars from 1950 to 1969. The reduction in production and price of cotton was a major factor in this decline. Other sectors which were below the average in earnings growth included transportation, communication, public utilities, and trade. Manufacturing and government stand out as relatively rapid growth sectors over the two decades.

The sector "Government" accounted for the largest percent of earnings in 1969. Of the sectors for which data are available, services ranked second, trade was third, and mining was fourth. Agriculture ranked next to last, accounting for only about four percent of total earnings.

The ranking of the sectors changed substantially over the two decades. In 1950, agriculture ranked first in proportion of earnings; while government and trade ranked a close second and third. In addition to agriculture, transportation, communication, utilities, and trade declined in relative importance over the period; while government, manufacturing, and services increased their proportion of total earnings. Mining showed a slight increase in its proportion of total earnings over the two decades.

TABLE 3.5
TOTAL PERSONAL INCOME AND TOTAL EARNINGS, 1950-1969, SANTA CRUZ-SAN PEDRO 4-COUNTY AREA

Item	1950	1959	1969	1950	1959	1969
	--Millions of 1967$--			--Percent-1969=100--		
Total Personal Income	424.3	860.9	1444.2	29.4	59.6	100
Total Earnings	344.3	708.5	1123.6	30.6	63.1	100
Agriculture	62.5	62.7	44.0	142.0	142.5	100
Forestry	0	1/	1/			
Mining	35.8	64.4	126.3	28.3	51.0	100
Contract Construction	(D)	(D)	(D)			
Manufacturing	15.2	79.5	82.5	18.4	96.4	100
Transportation, Communication, and Public Utilities	31.7	45.6	58.7	54.0	77.7	100
Wholesale and Retail Trade	56.7	109.7	156.7	36.2	70.0	100
Finance Insurance and Real Estate	(D)	(D)	(D)			
Services	44.9	89.1	175.1	25.6	50.9	100
Government	59.8	166.1	330.1	18.1	50.3	100
Civilian Government	40.3	102.1	223.6	18.0	45.7	100
Armed Forces	19.5	64.0	106.5	18.3	60.0	100
	--Percent of Earnings-- -----by Sector-----					
Total Earnings	100	100	100			
Agriculture	18.2	8.8	3.9			
Forestry	0	0	0			
Mining	10.4	9.1	11.2			
Contract Construction	(D)	(D)	(D)			
Manufacturing	4.4	11.2	7.3			
Transportation, Communication, and Public Utilities	9.2	6.4	5.2			
Wholesale and Retail Trade	16.5	15.5	13.9			
Finance Insurance and Real Estate	(D)	(D)	(D)			
Services	13.0	12.6	15.6			
Government	17.4	23.4	29.4			
Civilian Government	11.7	14.4	19.9			
Armed Forces	5.7	9.0	9.5			

Source: 1972 OBERS Projections, Vol. 4, p. 213.
1/ Less than one-tenth million.
(D) Deleted to avoid disclosure of data pertaining to an individual establishment.

CULTURAL, SCIENTIFIC, AND MILITARY INSTALLATIONS

Cultural and scientific centers within the study area include: the University of Arizona (a land grant institution) and Pima College at Tucson, Cochise College near Douglas, and Central Arizona College near Casa Grande and Coolidge. Students, faculty, and research personel number about 40,000.

Another scientific activity of national and international significance involves studies of the solar system and outer space. Research studies are conducted at the Kitt Peak National Observatory in the north end of the Baboquivari Mountains, the Mount Hopkins Observatory of the Smithsonian Institution located in the Santa Rita Mountains south of Tucson, and the Mount Lemmon Infra-red Observatory operated by the University of Arizona in the Santa Catalina Mountains north of Tucson. Initial investments in these observatories total about 43.7 million dollars. Operation and maintenance of the installations employ about 500 scientific and support personnel.

Two military bases which employ a substantial proportion of the Basin's government employees include Fort Huachuca in Cochise County and Davis-Monthan Air Base in Pima County. Fort Huachuca is a important military communication center and electronics proving ground. Besides operating military aircraft, Davis-Monthan Air Base plays an important role in national security by manning 18 inter-continental, ballistic-missle silos around the clock.

CROP ENTERPRISES

The output and value of crops produced within the study area in the base period are considered in this section, together with the irrigated acreage used for their production.

The irrigated acreage was derived from the Critical Ground Water Areas and Irrigated Lands Map, back of report. The acreage of each crop was estimated from data obtained from ASCS county records and judgement of specialists in each county. Production of each crop in Pima, Pinal, and Santa Cruz Counties was estimated on the basis of acreage, the assumption being that yields were the same within and outside the study area. In Cochise County, crop yields are less uniform. Moreover, the Bonita area in Graham County is included. Hence, base period production of crops in Cochise County (including the Bonita area in Graham County) was derived by multiplying acres by yields obtained from the soil resource group (SGR) data.

Value of Crop Production

The value of crop production given in Table 3.6 totalled nearly 101 million dollars in the base periods. Oil and fiber crops (primarily

TABLE 3-6

ESTIMATED CROP PRODUCTION AND VALUE IN THE SANTA CRUZ-SAN PEDRO RIVER BASINS, 1970 Normalized 1/

Comodity	Units	Production	Value
		--------1,000--------	-----$1,000-----
Feed Crops			
Barley	cwt.	1,469.4	3,791.1
Oats	cwt.	4.6	11.8
Grain Sorghum	cwt.	5,361.7	13,136.1
Corn	cwt.	56.1	145.9
Alfalfa Hay	tons	93.9	2,825.5
Other Hay	tons	31.5	932.4
Silage & Forage, all	tons	136.8	1,368.0
Cropland Pasture	aums	139.2	1,225.0
Pasture, Noncropland, Irrigated	aums	19.6	172.5
Subtotal			21,191.8
Food Crops			
Wheat	cwt.	1,261.8	3,179.7
Vegetables, Including Potatoes	cwt.	2,554.3	16,858.4
Citrus	tons	4.9	872.2
Noncitrus Fruits	tons	6.1	535.3
Nuts	cwt.	128.8	5,783.1
Sugar Beets for Sugar	tons	90.6	1,159.6
Sugar Beets for Seed	lbs.	54.5	32.7
Dry Beans	cwt.	10.0	92.3
Subtotal			28,513.3
Oil and Fiber Crops			
Cotton Lint			
Upland	lbs.	103,144.3	41,257.7 2/
Am.-Egyptian	lbs.	4,468.7	2,323.7 2/
Cotton Seed			
Upland	tons	87.0	4,564.0
Am.-Egyptian	tons	4.6	241.3
Safflower	cwt.	53.4	248.8
Subtotal			48,635.5
Total			100,757.1

1/ 1968-70 average for most crops.
2/ Includes price support payments.

cotton) comprised about 49 percent of the total, food crops 28 percent, and feed crops 23 percent. In the food crop group, vegetables comprised about 60 percent of the total, ranking second in dollar value to upland cotton in importance among crops produced in the basin. Among the feed crops, grain sorghum stands out. It accounted for about 56 percent of the group value and ranked third in value among crops produced in the study area.

Acreage of Irrigated Crops

The estimated acreage of irrigated crops harvested is given, by county, in Table 3.7. About 53 percent of the acreage was used for feed crop production, 16 percent for food crop production, and 31 percent for oil and fiber crop production. Less than one percent was used for minor crops. The proportional distribution of acreage was similar in Pima County but differed substantially in the other three counties. In Pinal County, about 47 percent of the acreage was devoted to oil and fiber crop production, 37 percent to feed crops, and 16 percent to food crops. In Cochise County, 75 percent of the acreage was used for feed crops, 17 percent for food crops, and seven percent for cotton production. In Santa Cruz County, 87 percent of the acreage was used for feed crops, 10 percent for food crops, and less than three percent for cotton production.

The dominant feed crops within the study area were grain sorghum, barley, and hay. These were also the major feed crops in each of the four counties, although the order of importance was different. Wheat and vegetables were the major food crops in the study area and also in Pinal County. However, in Pima County, pecans ranked first and vegetables second; while in Cochise County, wheat ranked first and sugar beets second. Upland cotton was the major oil and fiber crop in the study area as well as in each of the counties. American-Pima cotton also was important in Pinal and Pima Counties.

MAJOR LIVESTOCK ENTERPRISES

The total area in the study area useable for grazing by domestic livestock is about 8.1 million acres. About 31 percent of the grazing land is in private ownership, 31 percent state ownership, 15 percent in Indian Trust, and the remaining 23 percent is administered by the federal government.

The range forage production for livestock use in the study area is relatively low when compared with the original production capacity. Severe overuse was prevalent during the late 1800's and early 1900's. This, combined with normal cycles of low precipitation, has caused desirable plant species to decrease and to become replaced by less desirable species. Native forage production is highest per acre on the desert grasslands in the eastern part of the study area.

Lands that are suitable for use by domestic livestock will, under proper management, support a livestock industry indefinitely and continue to be an important and integral part of the economic framework of the study area.

TABLE 3.7

ESTIMATED ACREAGE OF IRRIGATED CROPS HARVESTED IN THE SANTA CRUZ-SAN PEDRO RIVER BASINS, 1970 Normalized 1/

Crop	Type IV Area	Pima County	Pinal County	Cochise County 2/	Santa Cruz County
Feed Crops					
Barley	42,478	9,833	28,018	4,327	300
Oats	207	-	207	-	-
Grain Sorghum,					
Total	108,917	16,733	21,639	70,278	267
Single	101,447	14,425	16,477	70,278	267
Double	7,470	2,308	5,162	-	-
Corn	1,537	-	390	1,123	24
Alfalfa hay	17,775	2,000	7,497	7,978	300
Other hay	10,673	1,004	7,091	1,664	914
Silage & forage	5,024	700	1,920	1,804	600
Pasture, cropland	12,894	2,022	6,276	3,769	827
Pasture, noncrpld. irg.	2,040	1,623	-	417	-
Subtotal	194,075	31,607	67,876	91,360	3,232
Food Crops					
Wheat	33,718	1,357	19,100	12,894	367
Vegetables 3/	12,281	2,135	8.373	1,773	-
Citrus	621	103	518	-	-
Noncitrus	1,639	315	-	1,324	-
Nuts	6,340	5,400	440	500	-
Sugar beets, Sugar	4,852	742	295	3.815	-
Subtotal	59,451	10,052	28,726	20,306	367
Oil and Fiber Crops					
Cotton, Upland	104,071	15,037	79,740	9,201	93
Cotton, Am.-Pima	3,049	2,313	5,736	104	-
Safflower	2,250	33	2,217	13	-
Subtotal	114,370	17,383	87,693	9,201	93
Minor Crops	1,995	471	300	1,154	30
Total	369,851	59,519	184,595	122,021	3,722

1/ 1968-70 average for most crops; excludes double cropped acres.
2/ Includes Bonita area in Graham County.
3/ Includes cantaloupes, melons and potatoes. The acreage given is "single crop" acreage.

Livestock use of rangelands in the study area is not commonly oriented toward producing the final livestock product. The ranges are generally more adaptable to the production of cattle and lambs to supply the feeder livestock industry. Beef cattle are the predominant class of range livestock produced in the study area. Livestock grazing operations often include fall, winter, and spring forage for weaner calves produced at higher elevations outside the study area. These animals partially supply the need for the feeder livestock industry. Ewes utilize the desert shrub and chaparral vegetative types for spring grazing from the time the lambs are weaned in February or March until ewes can again be moved to high elevations outside the study area in April and May.

Irrigated pasture is of substantial economic importance in livestock production and is generally used in dairy cattle, beef cattle, and sheep operations and for horses. Production is nearly six tons of dry forage per acre. The higher yielding grasses, legumes, and small grains are pastured. The aftermath of these and other crops is grazed after harvest.

The estimated numbers of range cattle, cattle in feedlots, milk cows, and sheep in Cochise, Santa Cruz, Pima, and Pinal Counties in 1970 are given in Table 3.9.

Maximum feeding capacity for the larger feed lot operations is near 250,000 cattle. The operations are located in Pinal County with some in Pima County. Smaller operations are also found in Cochise and Santa Cruz Counties.

The livestock industry developed as one of the basic industries in the study area during early settlement. In 1970, there were about 780 farms and ranches in the four-county area. The total gross output of the livestock industry in 1969 was about $121,000,000 (Table 3.8).

The trend is toward fewer and larger ranching operations. The demand for land by other uses tends to decrease the area suitable and available for grazing. The number of cattle on the range has not changed significantly; however, the total of all cattle increased steadily from 1970 to 1974 and decreased in 1975 to near the 1970. The number of cattle in feedlots caused the change.

FARM NUMBERS AND SIZE

The number of farms in the Santa Cruz-San Pedro four-county (Pima, Pinal, Cochise, and Santa Cruz) area totalled 1,676 in 1969. (See Table 3.10.) Of the total, 43 percent were in Cochise County, 29 percent in Pinal County, 20 percent in Pima County, and eight percent in Santa Cruz County.

The average size of all farms (including ranches) in the four-county area was 5,065 total acres and 435 harvested acres (see Table 3.10). Farms in Pima County were relatively large, averaging 10,865 total acres and 469 harvested acres. However, Pinal County farms were substantially

TABLE 3.8

NUMBER OF FARMS (RANCHES) AND GROSS INCOME BY MAJOR LIVESTOCK ENTERPRISE IN THE 4-COUNTY AREA,

SANTA CRUZ-SAN PEDRO RIVER BASINS

Livestock Enterprise	County				Total
	Cochise	Pima	Pinal	Santa Cruz	
Dairy					
No. Farms (Ranches)	10	4	7	-	21
Dollar Value (Thousands)	418	882	610	-	1,910
Hogs, Sheep, and Goats					
No. Farms (Ranches)	61	19	30	-	110
Dollar Value (Thosands)	333	927	1,086	-	2,346
Other Cattle and Calves					
No. Farms (Ranches)	291	134	133	91	649
Dollar Value (Thousands)	5,608	12,890	96,436	2,247	117,181

Source: 1969 Census of Agriculture, U.S. Department of Commerce, May 1972.

Note: Dash indicates small value.

TABLE 3.9

GENERAL KINDS OF LIVESTOCK ENTERPRISE AND ESTIMATED NUMBERS OF LIVESTOCK BY COUNTIES, SANTA CRUZ-SAN PEDRO RIVER BASINS 1/

County	Cow-Calf or Steer Operations	Feeder Cattle Operations	Dairy	Sheep 2/ & Lambs	Horses 4/
	(numbers in thousands)				
Cochise	45	-	-	-	4.4
Graham	6	-	-	-	.2
Pima	31	-	2	-	4.1
Pinal	53	102	1	-	1.9
Santa Cruz	23	-	-	-	2.4
Totals	158	102	3	22.1 3/	13

(General Kinds of Livestock Enterprise)

1/ Data Source - Arizona Agriculture Statistics, Bulletin S-7, March 1972 (page 59), Arizona Crop and Livestock Reporting Service (43).

Elmer L. Menzie, Department of Agricultural Economics, University of Arizona.

2/ Sheep and lambs not highly significant - some on rangeland but most on irrigated cropland during lambing season.

3/ Data not available by county.

4/ The majority of horses are used for pleasure riding. Some are kept on ranches and used in cattle operations.

TABLE 3.10

NUMBER AND AVERAGE SIZE OF FARMS IN THE

SANTA CRUZ-SAN PEDRO 4-COUNTY AREA, 1969 1/

	All Farms			Commercial Farms 2/		
		Acres per Farm			Acres per Farm	
County	No.	Total	Harvested 3/	No.	Total	Harvested 3/
Pima	343	10,865	469	238	5,415	674
Pinal	494	4,805	637	419	3.739	638
Cochise	713	2,953	236	503	4,071	290
Santa Cruz	126	2,254	66	96	2,857	69
4-County Area	1,676	5,065	435	1,256	4,122	487

1/ Source: 1969 U.S. Census of Agriculture for Arizona, p. 268. The census definition of a farm includes ranches.

2/ Farms with sales of $2,500 and over.

3/ Total acres reported divided by farms reporting.

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larger in terms of cropped acres, averaging 637 harvested acres and 4,806 total acres. Cochise County farms averaged 2,953 total acres and 236 harvested acres, while Santa Cruz County farms averaged 2,254 total acres and 66 harvested acres.

The number of commercial farms (census class 1-5 farms; i.e., farms with sales of $2,500 and over) in the four-county area totalled 1,256 in 1969, which was 75 percent of all farms (see Table 3.10). In Pima County 70 percent of all farms were classified as commercial farms, which averaged 5,415 total acres and 674 harvested acres. In Pinal County, commerical farms comprised 85 percent of all farms and averaged 3,739 total acres and 638 harvested acres. In Cochise County, 70 percent of all farms were commercial farms which averaged 4,071 total acres and 290 harvested acres; and in Santa Cruz County, commercial farms made up 76 percent of all farms and averaged 2,857 total acres and only 69 harvested acres.

The number of all farms declined from 1959 to 1969 in Pima, Pinal, and Cochise Counties but increased slightly in Santa Cruz County (see Table 3.11). The number of economic class 1-5 farms also declined in

TABLE 3.11

NUMBER OF ALL FARMS AND OF COMMERCIAL FARMS BY ECONOMIC CLASS IN 1969 AND 1959, SANTA CRUZ-SAN PEDRO 4-COUNTY AREA 1/

County and Year	All Farms	Class 1-5 Farms No.	Class 1-5 Farms Pct. 3/	Economic Class of Farm 2/ 1 No.	1 Pct. 3/	2 & 3 No.	2 & 3 Pct. 3/	4 & 5 No.	4 & 5 Pct. 3/
Pima									
1959	424	286	63	101	24	96	23	71	17
1969	343	238	69	74	22	69	20	95	28
1969/1959	.81	.89	--	.73	--	.72	--	1.34	--
Pinal									
1959	679	517	76	325	48	123	18	69	10
1969	494	419	85	263	53	96	19	60	12
1969/1959	.73	.81	--	.81	--	.78	--	.87	--
Cochise									
1959	824	497	60	76	9	252	31	169	20
1969	713	503	71	128	18	192	27	183	26
1969/1959	.87	1.01	--	1.68	--	.76	--	1.08	--
Santa Cruz									
1959	122	92	75	29	24	47	38	16	13
1969	126	96	76	18	14	33	26	45	36
1969/1959	1.03	1.04	--	.66	--	.70	--	2.81	--
4-County Area									
1959	2,049	1,374	67	531	26	518	26	325	15
1969	1,676	1,256	75	483	29	390	23	383	22
1969/1959	.82	.91	--	.91	--	.75	--	1.18	--

1/ Source: U.S. Census of Agriculture for Arizona

2/ Farm product sales per farm by class are as follows: Class 1 - $40,000 or more; Class 2 - $20,000-$39,999; Class 3 - $10,000-$19,999; Class 4 - $5,000-$9,999; and Class 5 - $2,500-$4,999.

3/ Percent of all farms. Sum of classes may not add to total due to rounding.

Pima and Pinal Counties but increased slightly in the other two counties. The largest relative decline in both groups of farms was in Pinal County where all farms declined 27 percent and class 1-5 farms declined 19 percent.

Cochise County stands out in the four-county area with a 68 percent increase in the number of class 1 ($40,000 or more of farm product sales) farms from 1959 to 1969. This trend is consistent with the large acreage of newly irrigated land developed in the county in recent years. The number of class 1 farms declined during the decade in the other three counties. However, the number in the class 4 and 5 group increased in all but Pinal County.

Compared with all farms, the relative number of class 1 and class 4 and 5 farms increased from 1959 to 1969 in the four-county area; while the relative number of farms in the class 2 and 3 groups declined.

The number of farms in the area has been declining over an extended period, and the average size of a farm has been increasing. This trend will likely continue throughout much and perhaps all of the projection period. The major trend probably will be toward larger commercial farms. Inherent in this trend will be movement of land to better managers which will be a factor in adoption of improved practices and various types of planned action and in increasing crop yields and production efficiency.

FOREST RESOURCES AND RELATED ECONOMIC ACTIVITY

Nearly all forest resources of the study area are within national forest boundaries. Therefore, economic activity related to forest resources on private, Indian Trust, BLM, and state lands is insignificant.

An estimated 5MM board feet of timber were harvested from the conifer forest on Mount Graham during 1969-70, but management of conifer forests is being redirected toward serving recreational needs and the production of water. In the Santa Catalina Mountains, a small logging operation is adjusted to salvaging trees being removed for roads, camping areas, skiing courses, and control of disease and insect infested trees.

Lacking enough material to support a profitable lumber operation, logging has been practically abandoned in the Santa Rita and Huachuca Mountains. Because of limited supplies and the establishment of a national monument and a wilderness area, commercial harvests of timber have been greatly reduced in the Chiricahua Mountains. The commercial harvest of forest products in the Graham Mountains, of which about half is in the study area, will be re-oriented to salvage operations to best serve growing demands for recreational activities.

The sale of 4,563 Christmas trees on forest lands returned $4,730.50 to the Federal Government during 1970 (Table 3.12). Sale of 50 bushels of pine cones, two tons of manzanita, and 30 tons of bear grass returned $388.85. The sale of 822.19 MBF of fence posts, firewood, and commercial lumber returned $2,658.79 during 1970.

TABLE 3.12

FEES PAID FOR TIMBER AND WOOD PRODUCTS HARVESTED ON

THE CORONADO NATIONAL FOREST

SANTA CRUZ-SAN PEDRO RIVER BASINS, 1970

County and Ranger District	Products	Units	Quantity	Fees Paid
Cochise County				
Douglas RD	Lumber & Wood	MBF 1/	282.74	736.00
	Christmas Trees	Number	1,998	2,036.40
	Bear Grass	Ton	30	373.85
Patagonia RD	Lumber & Wood	MBF	55	110.00
	Christmas Trees	Number	5	5.00
Willcox RD	Lumber & Wood	MBF	26.75	700.00
	Christmas Trees	Number	2	2.00
Graham County				
Safford RD	Lumber & Wood	MBF	61.15	74.00
	Christmas Trees	Number	2,546	2,663.10
Pima County				
Santa Catalina	Lumber & Wood	MBF	135.65	506.66
	Christmas Trees	Number	12	24.00
	Manzanita	Ton	1	5.00
Santa Cruz County				
Nogales	Lumber & Wood	MBF	210	420.25
	Manzanita	Ton	2	10.00
Santa Rita	Lumber & Wood	MBF	50.90	111.88
	Pine Cones	Bushels	50	5.00
Total				7,783.14

1/ MBF = Thousands of Board Feet.

Numbers of livestock grazing conifer forests and woodland-chaparral ranges have been constantly reduced because of past overstocking and related problems. Closures to grazing use associated with the creation of national monuments, research, and recreation areas have added to reductions in livestock numbers.

Increases in forage producing areas from on-going programs have not been applied on a scale large enough to offset losses in forage.

Commercial radio and television relay stations and radio transmitting stations for state and federal law enforcement agencies and for private organizations are located on a few of the high mountain tops.

MINING

Mining plays an important note in the economy of the study area. Of all the different minerals, copper is the most important. Eight of the 15 leading copper producing mines in Arizona in 1970 were located in the study area. Copper's importance is further emphasized by the fact that Arizona, during that same year, produced 53 percent of the nation's copper and supported 16 of the nation's leading mines.

Other minerals also are important. The value of mineral production and principal minerals are exhibited in Table 3.13.

TABLE 3.13
VALUE OF MINERAL PRODUCTION AND PRINCIPAL MINERALS PRODUCED BY COUNTY, 1969-70

County	Value of Production 1969 ($000)	Value of Production 1970 ($000)	Principal Mineral Produced
Cochise	65,157	78,297	Copper, lime, silver, stone, gold, sand
Pima	251,563	422,298	Copper, cement, molybdenum, gold
Pinal	212,540	285,166	Copper, molybdenum, silver, gold, sand and gravel
Santa Cruz	W 1/	W 1/	Sand, gravel, silver, stone, leak

1/ W - Withheld to avoid disclosing individual company data.

OUTDOOR RECREATION, TOURIST ATTRACTIONS, AND RELATED ACTIVITY

In modern times, recreation and tourism have played an important role in the financial returns to local people and in providing satisfactions to the consumers involved in such activities as picnicking, camping, fishing, boating, swimming, hiking, and hunting (see Table 3.14). Demands for these activities and the related space needed have grown with population and with transportation facilities. More than five million visitors have sought recreational satisfactions in recent years at national forest facilities, national monuments, state parks, and at private and semi-private facilities.

Outdoor recreational uses and related activities are influenced by climate, natural and manmade attractions, and numbers of people. During the hot summers, local residents travel to cool mountain recreation areas for brief relief from high temperatures. In contrast, mild winter temperatures attract visitors from the colder states. Tourism studies by the University of Arizona in 1972 indicate that 70 percent of the highway travelers entering the study area by major east-west and north-south highways were in passenger vehicles. Two-thirds of these were couples. Of the motorists entering the area, 37 percent were traveling for recreation, 24 percent for visiting friends, 15 percent for changing addresses, 12 percent for returning home, and the rest were on business. Travelers depend on communities along major routes to provide food, lodging, fuel, and services.

Demands for recreation have increased with population growth, increased leisure time, and improved financial status. Arizona's demand for recreation increased 36 percent during the 1960's. (38) Population growth has been partially the result of establishment and growth of retirement communities such as Green Valley. Many retired people have the time and money to enjoy surrounding recreational activities.

More than half of the five million recreation visits made during 1970 involved state parks and federal lands managed by the Forest Service, National Park Service, Bureau of Land Management, and lands of the Papago Indian Reservation. Table 3.14 exhibits data on activities, sites, visits, and fees relating to outdoor recreation facilities. For instance, Forest Service land developed for picnicking and camping served about 1.8 million people in 1970. These areas are designed to serve from 15 to 300 persons at one time. Picnic areas are available for use by several different families in a single day. Annual fees totalled $130,908 for special-use permits and charges for campground use.

The number of visits varied considerably among sites. About 68,700 people visited the mission and museum of the Tumacacori National Monument in 1970, while 117,000 visited the Casa Grande Indian Ruins National Monument. The Saguaro National Monument had 323,300 visits in 1970. (39)

TABLE 3.14

OUTDOOR RECREATION SUMMARY,
FOREST SERVICE, PARK SERICE,
STATE AND PRIVATE FACILITIES

SANTA CRUZ-SAN PEDRO RIVER BASINS, 1970

Organization	Type of Activity 1/	Number of Sites	Number of Visits	Annual Fees Collected (Where Known)
Coronado National Forest	O,P,C,F,B,S,H,R	58	1,876,282	$ 130.908
Bureau of Land Management 2/	O,P,C,H,R	1	5,950	--
National Monuments	O,P,C,H,R	5	613,000	73,435
State Parks and Lakes 3/	O,P,C,H,F,B,	4	209,785	34,315
Private & Semi-Private				
No Fee		5	1,507,000	
Fee Charge		6	796,000	1,538,818
Total		75	5,002,067	$1,777,476

1/ Types of Activity

O - Observing
P - Picnicking
C - Camping
F - Fishing
B - Boating
S - Swimming
H - Hiking
R - Horseback Riding

2/ By owning private lands at east and west entrances to Aravaipa Canyon Primitive Area, Defenders of Wildlife have attempted to exercise control over visitors. Particular emphasis is placed on denying hunters access to state and public lands north and south of the primitive area.

3/ There was no information available on the use made of Arivaca Lake, which was completed in 1971.

Visitor rates per reserved acre also varied considerably. The Saguaro National Monument, comprised of about 79,080 acres, had an overall annual use of four visitors per reserved acre. But the 25,980 acres accessible to motorized traffic was used at the annual rate of twelve persons per reserved acre. The Chiricahua National Monument was used at the rate of five visitors per reserved acre.

Photograph 11
Aerial view of Chiricahua National Monument *(FS Photograph)*

Wilderness areas are reserved for hikers and horseback riders. Compared to areas with organized camping and picnicking grounds designed to satisfy the needs of many people, wilderness areas are used by a comparatively few but increasing number of people. The Chiricahua Wilderness area, which represents a use ratio of 1 to 25 when compared to the adjacent national monument, was used in 1970 at the rate of five reserved acres per visitor. In the Saguaro National Monument, 700 people used the trails and overnight camping sites within the 53,100 acres of "back country", resulting in a use rate of one person per 75 reserved acres. 1/

Aravaipa Canyon Primitive Area is the only recreation area managed by the Bureau of Land Management. Although not heavily used at present, a daily limit of 50 visitors has been tentatively set by the Bureau. The length of visit has been tentatively set at three days and two nights and the size of groups has been restricted to ten indviduals. Since entrance permits are required, rate of use can be controlled by the Bureau.

1/ National Park Service, 1973.

Photograph 12
Aravaipa Canyon *(FS Photograph)*

Of thirteen private and semi-public recreational attractions located in the vicinities of Tucson and Tombstone, six require entrance fees and seven are without charge. The five main attractions without a set charge were visited by 1.5 million people. These five are Tucson Mountain Park, Kitt Peak Observatory, San Xavier del Bac Mission, and the famous Rose Tree Inn and Boothill Cemetery in Tombstone. The Rose Tree, a banksia rose planted almost a century ago, has survived the prosperous mining boom of Tombstone and the violent men who lived, died, and were buried in Boothill Cemetery. No records are kept on the number of people who visit the other two no-fee attractions, the Lavender Pit mining excavation of Phelps Dodge Corporation near Bisbee and the Military Museum at Fort Huachuca.

Attractions for which 796,000 visitors paid $1,538,818 in fees in the base year included Arizona-Sonoran Desert Museum and Old Tucson located west of Tucson; Colossal Cave northeast of Tucson; Patagonia Lake located between Nogales and Patagonia; and the OK Corral and Wells Fargo attractions at Tombstone. The Arizona-Sonoran Desert Museum is an outstanding educational display of native desert vegetation, animals, birds, insects, and related land and water relationships. Patagonia Lake 1/ is a highly popular fishing, boating, picnicking, and camping attraction. Two other very popular lakes are Pena Blanca near Nogales

1/ Ownership of Patagonia Lake changed from private to a State Park in 1975. Management is by the Arizona Game and Fish Department and the Arizona Parks Board.

Photograph 13
Aerial View of Kitt Peak National Observatory *(FS Photograph)*

Photograph 14
San Xavier del Bac Mission *(FS Photograph)*

and Parker Canyon near Fort Huachuca. Both are in the Coronado National Forest and are operated and managed by the Arizona Game and Fish Department. The associated campgrounds and related facilities are maintained and operated by the Forest Service.

Photographs 15 and 16
Fishing, boating, camping, and picnicking are available at Patagonia Lake (above) and Pena Blanca Lake (below). Swimming facilities are also available at Patagonia Lake. *(FS Photographs)*

Table 3.15 provides a summary of recreation facilities available through school, city, county, and private parks, as well as federal installations. Picnic tables, ramadas, and camping spaces include those of previously described national parks and forests.

Multiple-use courts, playing fields, and playgrounds are mostly associated with schools, county, and municipal parks. Tennis courts, golf courses, and swimming pools are those of city, county, and private enterprises. During times of economic insecurity, closure of national forests for fire protection, and high costs of motor fuels, recreation is directed more toward the use of nearby recreation facilities. Trips to sites located farther away receive more careful planning and are usually for longer stays.

Organization camps provide recreation for groups of people having a common identity (Table 3.16). Within the Coronado National Forest, these groups include: Boy Scouts of America, Saguaro Girls Scouts of America, Methodist, Presbyterian, Catalina Baptist, Latter Day Saints, Southern Arizona Bible Camp, and Amphitheater Mens Club. The forest area under permit for use as organization camps totals 78 acres. Annual permits return $483 to the U.S. Treasury. Use of organization camps was 117.1 user days in 1974.

There are 451 summer recreational homes and cabins occupying 279 acres of national forest land. Table 3.16 shows the number of homes by ranger district and county. Annual fees paid for this permitted use total $54,827.50, probably the highest return realized by the Federal Government for Coronado National Forest lands. The number of people using these homes, including families and guests, is estimated to be no more than 3,000. This results in a estimated 400,000 visitor days.

TABLE 3.15

SUMMARY OF RECREATION FACILITIES, SANTA CRUZ SAN PEDRO RIVER BASINS, 1971

Recreation Facilities	Number
1. Picnic tables	1,712
2. Picnic ramadas	134
3. Camping spaces	1,675
4. Multiple-use courts	531
5. Playing fields	692
6. Playgrounds (acres)	91
7. Tennis courts	235
8. a. Swimming facilities	129
b. Beaches	3
9. Quarter-mile oval tracks	29
10. Golf courses (number of holes)	329
11. Walking trails (most are also available for horseback).	760 Mi.
12. Equestrian gymkhana arena	5
13. Group camps	4
14. Boat ramps	9
15. Other (Snowmobile course, all terrain vehicle courses, trails accessible to the handicapped).	4

TABLE 3.16

NUMBER, AREA OCCUPIED, AND RETURNS FOR SUMMER RECREATIONAL HOMES AND ORGANIZATIONAL CAMPS BY COUNTY AND RANGER DISTRICT, CORONADO NATIONAL FOREST, SANTA CRUZ-SAN PEDRO RIVER BASINS, 1970.

County & Ranger Dist.	Summer Recreational Homes			Organizational Camps 1/		
	Number of Homes	Total Area (acres)	Annual Fees Paid (dollars)	Number of Camps	Area (Acres)	Annual Fees Paid (dollars)
Cochise County						
Douglas RD	30	14	2,625.00	2	25	173.00
Graham County						
Safford RD	95	26	8,312.50	2	6	69.00
Pima County						
Santa Catalina RD	296	224	40,890.00	6	35	216.00
Santa Cruz County						
Santa Rita RD	30	15	3,000.00	-	-	-
Pinal County						
Santa Catalina RD	-	-	-	1	12	25.00
Total	451	279	54,827.50	11	78	483.00

1/ Organization camps include Boy Scouts of America, Girl Scouts of America, Methodist, Presbyterian, Catalina Baptist, Latter Day Saints, Southern Arizona Bible Camp, and Amphitheater Mens Club.

CHAPTER 4

PRESENT LAND AND WATER USE

HISTORY OF LAND USE

Agriculture was practiced more than 2,000 years ago by the Hohokam Indians, ancestors to the present-day Pimas. 1/ A network of more than 600 miles of canals, two to four feet wide and two feet deep, are reported to have covered the Gila and Salt River valleys. Indian farmers grew such irrigated crops as cotton, corn, beans, and squash. Pima, Papago, and nomadic Apaches also used native plants for food, fiber, and shelter.

Agricultural activities were further developed in the 1690's. Father Kino, a Spanish missionary, introduced new crops such as wheat and diversified farming by including the breeding and raising of horses, cattle, sheep, and goats. In the 1880's, the expansion of agricultural activity was aided by the arrival of the transcontinental railroad in Tucson. Transportation of perishable food products from desert farmlands producing two crops annually was further advanced by the invention and development of internal combustion engines. Combustion engines and electrical motors used for pumping water have resulted in the expansion of farming into areas where irrigation is completely dependent on ground water supplies. Production of crops has been materially increased with greater efficiencies in applications of irrigation water, with applications of fertilizers, and with control of weeds, insects, and plant diseases through applications of pesticides. While the net area in farms has increased since settlement, some losses have occurred where lands have been converted to urban and other uses.

Although Coronado is reported to have introduced 1,000 horses, 500 cattle, and 500 sheep during his expedition of 1549, the early development of ranching was more actively encouraged by Father Kino. Ranching remained at a low level during the unstable period associated with the Mexican War for Independence, the war between the United States and Mexico, and the U.S. Civil War. The Gadsden Purchase of 1853 allowed ranching to emerge again after the Civil War.

Conifer forest covering limited areas on the tops of scattered mountain ranges provided lumber and wood products for settlers, ranchers, miners, and army posts. Lumber was first produced in the Santa Rita Mountains in 1856. Mine timbers were harvested from the nearest mountains as mining activities developed. Lumber and wood products were harvested by the Army for Fort Huachuca from the adjoining mountains. Logging in the Chiricahua Mountains that once served the needs of ranchers and miners has been greatly reduced by the establishment of the Chiricahua Wilderness.

1/ National Park Service, 1971

Although some mining was practiced during the periods of Spanish and Mexican influence, the establishment of numerous mining communities began soon after the Gadsden Purchase. A number of mining towns were settled between Arivaca and Dos Cabezas during the 50-year period between 1860 and 1910. Only ruins mark the locations of some of these early-day mining communities, while a few such as Tombstone have survived.

Development of large mechanized equipment and improved metallurgical methods have made possible the mining of low grade ores and the excavation of large pits such as the Phelps Dodge Lavender Pit at Bisbee. Although Phelps Dodge has closed down operations at Bisbee, new mining operations have been opened by eight companies south of Tucson, on the Papago Indian Reservation near Casa Grande, and at San Manuel. Production of copper and associated metals from these mines within the Santa Cruz-San Pedro River Basin makes a large contribution to Arizona's total mineral production.

PRESENT LAND USE

Cultivation

A total of over 390,000 acres were used for crop production in 1970 within the Santa Cruz-San Pedro River Basins. (See Table 4.1.) In addition, there were nearly 160,000 idle developed acres, making a total of 550,000 acres developed for irrigation. The acreage in highways, roads, ditches, farmsteads, etc., within the irrigated area was estimated to total about 40,000 acres, bringing the total to 590,000 acres in the irrigated area. (See the Critical Ground Water and Irrigated Lands Map).

Most of the idle developed acreage for irrigation was in Pinal County. Cochise County also had a substantial amount of idle developed acreage. While the idle acreage in Santa Cruz County was small compared with Pinal and Cochise Counties, it comprised a large percentage of the total acreage developed for irrigation in the county. In contrast, practically all of the irrigated acreage in Pima County was used for crop production.

Grazing

Federal and Indian Lands

The rate at which livestock was being brought into the study area began decreasing after 1885 and peaked in 1891. After the drought and death occurrence of 1893, people realized that some means of controlling stocking rates had to be instituted. Creation of the Coronado National Forest soon after the turn of the century and the establishment of the Papago and San Xavier Indian reservations initiated the first controls over grazing. Initial controls on national forest land were obtained by fencing exterior boundaries and dividing interior areas into grazing allotments assigned to designated ranching operations. These controls

TABLE 4.1

ACREAGE IN CULTIVATION AND RELATED USES IN 1970 NORMALIZED, 1/

SANTA CRUZ-SAN PEDRO RIVER BASINS, BY COUNTY

Item	Study Area 2/	Pima County 2/	Pinal County 2/	Cochise County 2/	Santa Cruz County 2/
			(1000 acres)		
1. Acres harvested 3/	369.8	59.5	184.6	122.0	3.7
2. Acres used for crop production4/	391.3	62.1	198.4	127.0	3.8
3. Nonharvested acres (L2-L.1)	21.5	2.6	13.8	5.0	.1
4. Irrigated acreage	549.1	63.7	330.1	148.8	6.5
5. Idle irrigated acreage (L.4-L.2) 5/	157.8	1.6	131.7	21.8	2.7
6. Highways, roads, ditches, farmsteads, etc. 6/	40.9	4.3	24.9	11.2	.5
7. Total acres in irrigated area (L4 + L6) 6/	590.0	68.0	355.0	160.0	7.0

1/ 1968-70 average for most crops. Other land uses were estimated as of 1970.
2/ Hydrologic area. Cochise County figures include Bonita area in Graham County.
3/ Single cropped acreage. Includes noncropland pasture irrigated in base period--Pima County 1623 acres and Cochise County 591 acres.
4/ Planted acres for all crops, excluding double cropped acreage, plus acreage in skipped rows in cotton.
5/ Excludes land in skipped rows in cotton.
6/ Within the irrigated area; does not include urban areas.

lead to adjusting numbers of livestock to levels of grazing that would favor maintaining the forage base which became the object of range management.

Unlike ranges in private ownership, national forest ranges have not been reduced by either conversions to cropland or speculative real estate development. Grazing has been phased out, however, on some national forest lands in rough country having low livestock carrying capacities and in or adjacent to areas receiving increasing recreational use. Wilderness areas of the Coronado National Forest are still being grazed.

Twenty percent of the private rangelands have been converted to cropland; two percent to urban areas; and nine percent to speculative land developments.

The establishment of fenced highway and railroad rights-of-way, which has removed sizeable acreages of rangelands of some ownerships, has had a more limited effect on national forest ranges.

Representative grazing capacities shown in Table 4.2 were developed and adapted from research data reported by the University of Arizona, Rocky Mountain Forest and Range Experiment Station, Coronado National Forest, Bureau of Land Management, Soil Conservation Service, and Bureau of Indian Affairs. In both the pine mixed-conifer and oak woodland-chaparral types, the less overstory canopy of trees and shrubs the greater the understory cover of grasses and forbs. Consequently, only 3.5 and 4.0 acres are needed to support an animal unit month (AUM) of grazing where the canopy of trees and shrubs is less than 30 percent. An AUM is a measure of forage required to maintain one animal unit for a period of 30 days. An animal unit is roughly one cow, one horse, one mule, five sheep, five swine, or six goats. Forage production decreases with increasing canopy of overstory trees and shrubs with a resultant increase in the number of acres needed to supply enough forage for an AUM of grazing. Desert grasslands provide the best grazing where these rangelands have been kept free from invasions by woody species.

The Gila and Maricopa Indian tribes, in cooperation with non-Indians of the San Carlos Irrigation and Drainage District, have changed large tracts of desert to irrigated croplands within the study area.

Table 4.3 shows the grazing use by animal numbers and AUM's of grazing during 1970 for the seven ranger districts of the Coronado National Forest and private lands within the national forest boundaries. For all ranger districts, 1,120,156 acres of the Coronado National Forest provide 24,533 animals with 232,994 AUM's of grazing or 4.8 acres per AUM.

The area of the Papago and San Xavier Indian reservation lands within the study area totals 1,405,259 acres. The large part of the Papago Indian Reservation, being Sonoran Desert, has been used mainly for grazing. It includes some of the most arid lands in the study area. The Papago Indian Reservation provided 104,200 AUM's of grazing after the severe drought of 1969.

National reserve lands administered by the BLM provide grazing on about 650,000 acres. These lands presently produce about 84,000 AUM's forage on Sonoran Desert and desert grasslands. Management plans are being developed to improve the lands as rapidly as possible. Under present condition, the management plans will be available during the 1980 to 1990 time period.

TABLE 4.2

REPRESENTATIVE GRAZING CAPACITIES FOR VEGETATION TYPES

	Acres/AUM
Riparian	
Closed stands of dense young trees	0
Open stands of mature trees	3.5
Pine Mixed-Conifer (summer use only)	
Less than 30 percent canopy	3.5
31-60 percent canopy	8.0
61 percent plus	16.0
Oak Woodland-Chaparral	
Less than 30 percent canopy	4.0
31-60 percent	5.5
61 percent plus	9.0
Desert Grassland	
Higher elevations	4.0
Lower elevations	5.0
Desert	
Sonoran (except for years of high winter precipitation and large quantities of annuals)	9.0
Chihuahuan	5.0
Area converted to grass	3.5

TABLE 4.3

GRAZING USE FOR 1970 BY ANIMAL NUMBERS AND
ANIMAL UNIT MONTHS ON ACRES OF USABLE
NATIONAL FOREST RANGES AND WAIVED PRIVATE LANDS

	Grazing Use		Acres Usable Range	
Ranger Districts	No. of Animals	AUM's	National Forest Lands	Waived Private Lands 1/
Santa Catalina	2,561	24,104	167,199	3,400
Santa Rita	3,894	38,301	196,761	6,700
Patagonia	5,942	61,674	247,748	19,991
Willcox	3,154	23,863	127,703	632
Douglas 2/	3,045	22,189	168,149	3,307
Nogales 2/	4,847	55,626	131,280	4,200
Safford 2/	1,090	7,237	43,095	-
Total	24,533	232,994	1,081,935	38,230

1/ Waived private lands have the stocking rate set by the Forest Service.
2/ Excludes areas of ranger districts outside study area.

Private and State Lands

There are about 5,243,000 acres of private and state grasslands and woodlands used for grazing by domestic livestock. About 2,543,000 acres are state owned lands. (See Table 4.2, the Vegetation, Croplands, Urban, and Mining Areas Map, and the General Soil Map).

The grasslands in Cochise and Graham Counties are generally in broad valleys from north of Willcox to the Mexico border. Gently sloping topography with deep soils at elevations ranging from 4,000 to 5,000 feet predominate. The sides of the valleys have some rocky hills, generally with a partial cover of trees. Production of these grasslands ranges from less than three acres for an AUM of grazing (approximately 800 pounds of day forage) to more than six acres per AUM.

Grasslands in Santa Cruz County are associated with moderately sloping topography. Deep clayey soils characterize the eastern portion. More gravelly clay soils are in the western portion adjacent to the Santa Cruz

River to 5,500 feet to the east. Forage production is good and ranges from less than three to about six acres to support an AUM. The latter is on a relatively small portion of grassland occurring on steeper, rocky slopes and shallow soil.

The eastern portion of Pima and Pinal Counties contains elevations similar to the lower elevations in Santa Cruz County. Production of forage decreases to the north as precipitation is lower and temperatures are higher. Generally, the forage produced ranges from about four acres per AUM to more than ten acres per AUM depending on the range site involved and precipitation.

Grasslands in the central portion of Pima County are in the Sonoran Desert. Broad valleys, with gently sloping sides and some mountains, range in elevation from about 3,000 to 4,000 feet. Production is extremely variable but less than all other grasslands.

The woodlands are generally oak woodland-chaparral. Production varies with canopy cover of trees and ranges from about five acres per AUM to more than nine acres per AUM.

Area grazed and production by counties is shown in Table 4.4.

Problems on grazing lands include overuse of the forage in times past, insufficient distribution of watering facilities, increases in woody plants that compete with forage grasses and shrubs, and insufficient management to improve production to the potential of the natural resources.

TABLE 4.4

APPROXIMATE AREA GRAZED BY DOMESTIC LIVESTOCK AND PRODUCTION ON STATE AND PRIVATE LANDS

County	Area Grazed	Present Production	Average Acres per AUM
	1000 Acres	1000 AUM's	
Cochise	1,932	500	3.9
Graham	304	52	5.9
Pima	1,476	184	8.0
Pinal	1,184	135	8.8
Santa Cruz	347	100	3.5
Totals	5,243	971	5.4

Timber and Wood Production

Presently, none of the study area is classified as commercial forest. Lumbering activities which occurred during the settlement period were discontinued when the transcontinental railroads facilitated importing lumber from other areas. Forest management generally aimed at providing a sustained yield of commercial lumber has been gradually revised toward a form of management that best serves recreation needs of people living in the desert towns and cities. This is exemplified by the Chiricahua

Mountains which have been taken out of production of wood products and placed in a national monument and a wilderness area. The forested areas at higher mountainous elevations have numerous uses such as varied recreation activities and various types of nature studies. With emphasis on these activities, lumbering activities are largely limited to salvage operations. Although a ten-year plan for timber management of the conifer forests in the Graham Mountain Range is still in operation, it is gradually being changed to meet increasing recreational demands.

Urban and Industrial

Urban and industrial centers occupied 75,093 acres in 1970. Surrounding satellite suburban communities and isolated housing developments added another 305,319 acres. In some of the more recent subdivision developments, homes are either widely scattered or completely lacking, with ownership merely identified by property line stakes and signs facing newly graded roads.

Residential and commercial developments are encroaching onto farmlands around Casa Grande, Coolidge, Florence, Eloy, and Maricopa (the main farming centers in Pinal County).

Satellite communities are becoming established around Tucson in the following areas (1) along Interstate Highway 19 south of Tucson, (2) along Interstate Highway 10 to the southeast, (3) along the Redington Road to the east, (4) along U.S. Highway 80 to the north, (5) along Interstate Highway 10 to the northwest, (6) in the vicinity of the Tucson Mountain Park area to the west, and (7) along State Highway 86 and 286 to the southwest. A considerable amount of the growth south of Tucson is associated with the large open-pit mining activities in that area. Population increases of 210,500 people for Tucson between 1950 and 1970 resulted in urban growth which largely displaced Sonoran Desert. There is a limited displacement of croplands along the Santa Cruz River. New subdivisions in Santa Cruz County and southeastern Pima County, such as those around Arivaca, Patagonia, Sonoita, and Lochiel are displacing grasslands.

In Santa Cruz County, subdivisions around Nogales are related to both city planning and planning by private developers. Residential and urban development north of Nogales, as planned, would displace limited farm and pasture lands along the Santa Cruz River and larger areas of the Sonoran Desert, desert grasslands, and woodland-chaparral.

In Cochise County, satellite communities are developing rapidly around Fort Huachuca and in an area extending from Sierra Vista to the International Boundary. New housing developments have been located around Tombstone, Willcox, and Benson. Two large tracts, platted for housing developments that are remote from established urban communities, are located in the Sulphur Springs valley. One is located between the Pearce-Cochise Highway and the Dragoon Mountains. The other is located east of the Elfrida-Sunizona Highway. Both of these developments have been carved out of highly productive desert grassland.

Land used for historical parks, national monuments, natural areas, wilderness areas, and picnic and camping sites totalled 169,420 acres in 1970 (Table 4.5). Wilderness, defined by the Wilderness Act, Public Law 88-577, is "an area where the earth and its community of life are untrammeled by man...an area of undeveloped federal land retaining its primeval character and influence without permanent improvements or human habitation, which is protected and managed so as to preserve its natural conditions..."

The following sections describe recreation areas administered by various agencies.

Forest Service

Designated recreation land administered by the Forest Service in the study area totals 63,823 acres. Of this total, 464 acres occur on 43 camping and picnicking areas. The remaining acreage consists of 58,217 acres in wilderness areas and 5,142 acres in natural areas.

Wilderness areas in the Çoronado National Forest which lie within the study area include the 52,717 acres of the Gailuro Wilderness and 5,500 of the total 18,000 acres of the Chiricahua Wilderness area. The areas are reserved for visitors who can travel through the wilderness either on foot or on horseback.

National Park Service

The National Park Service administers five national monuments of which Saguaro National Monument is the largest. This monument covers 79,083 acres and is divided into two parts (Table 4.5), of which 63,723 acres are located east of Tucson and 15,360 acres are located west of Tucson. The monument was established in 1933 to protect a very fine stand of saguaro (giant cactus). About 53,100 acres in the "back country" are managed as wilderness. The area ranges from the Sonoran Desert at 3,100 feet to the conifer forest at 8,600 feet in the Rincon Mountains. By covering the trails either on foot or horseback, visitors have an excellent opportunity to become acquainted with plants, animals, and birds of the Sonoran Desert, oak-juniper woodlands, chaparral, and conifer forests.

The Chiricahua National Monument in the southeast part of the study area was established in 1924 on 10,887 acres of unusual formations of pinnacles, cliffs, spires, and balanced rocks. The monument has 37 campsites provided with water and fireplaces. In addition to the unusual rock formations, the monument provides an opportunity to study plants, animals, birds, and history involving Chiricahua Apache Indians and Spaniards.

The Coronado National Memorial is located along the United States-Mexico International Boundary about midway between Douglas and Nogales. Literature about the 1,060-acre memorial describes the colorful events related to the Coronado Peak and Montezuma Pass and shows the location of a picnic area.

TABLE 4.5

NUMBER AND SIZE OF FEDERAL AND STATE PICNIC AND CAMPING AREAS, WILDERNESS AREAS, NATURAL AREAS, NATIONAL MONUMENTS, AND HISTORICAL PARKS

Administering Agency	County	Ranger District, Park, Monument, Etc.	Unit	No. of Units	Size (Acres)
Arizona State Parks	Cochise	Tombstone Courthouse	Historic Monument	1	1
		Patagonia Lake	Recreation Park	1	640
	Pinal	Picacho Peak	Recreation Park	1	3,400
		Florence Courthouse	Historic Park	1	2
	Santa Cruz	Tubac Presidio	Historic Park	1	10
Forest Service	Cochise	Douglas Ranger Distr.	Campground	9	55
		Patagonia Ranger Distr.	Campground	2	41
		Willcox Ranger Distr.	Campground	1	8
		Chiricahua	Wilderness Area	1	5,500
	Graham	Safford Ranger Distr.	Campground	5	30
		Galiuro	Wilderness Area	1	52,717
	Pima	Santa Catalina Ranger District	Campground	20	285
		Santa Catalina	Natural Area	1	4,138
		Butterfly Peak	Natural Area	1	1,004
	Santa Cruz	Nogales Ranger Distr.	Campground	4	23
		Santa Rita Ranger District	Campground	1	12
	Pinal	Santa Catalina Ranger District	Campground	1	10
National Park Service	Cochise	Chiricahua	National Monument	1	10,887
		Coronado	National Monument	1	1,060
	Pima	Saguaro	National Monument	1	79,083
	Pinal	Casa Grande Indian Ruins	National Monument	1	472
	Santa Cruz	Tumacacori	National Monument	1	10
Bureau of Land Management	Pinal	Aravaipa Canyon	Primitive Area 1/	1	4,357
Papago Indian Reservation	Pima	Kitt Peak Observatory	Picnic Area	1	5
		San Zavier Del bac Mission	Mission	1	-
Private	Pinal & Graham	Aravaipa Canyon	Natural Area 1/	1	5,670
Total					169,420

1/ A contiguous area administered by two different entities but managed as one unit.

Casa Grande Ruins National Monument, located near Coolidge, is an Indian ceremonial structure reported to have been built about 1350. From various bits of evidence about the 472-acre monument, it has been determined that the Indians of that time built extensive irrigation systems in the Salt and Gila River valleys.

Tumacacori National Monument is a well preserved Spanish mission reported to have been built by Indians around 1698, under the leadership of Father Eusebio Francisco Kino. Located on ten acres, the Tumacacori Mission is related to a number of historical events which led to the abandonment of the mission and the transfer of furnishings to the San Xavier Mission near Tucson.

Bureau of Land Management

Aravaipa Canyon was set aside by the Secretary of the Interior as a primitive area in 1969, under the administrative management of the Bureau of Land Management. 1/

Management is directed toward protecting, maintaining, and enhancing natural beauty, ecological systems, wildlife, environment, historical features, and scientific values of the area. The area administered by the Bureau consists of 4,357 acres. About 5,670 acres adjacent to the 4,357 acres is owned by Defenders of Wildlife, a private entity.

Arizona State Parks

State parks and lakes within the study area include the Tombstone Courthouse, Florence Courthouse, the Tubac Presidio, Picacho Peak, and Patagonia Lake. The State Parks Department was established comparatively recently. Therefore, land acquisitions by the State Parks Board are new. The Tombstone Courthouse is a Victorian structure dating back to the 1880's.

The Florence Courthouse (original) was constructed of adobe in 1877-88 at a cost of $2,700. Cases were tried here by two future Arizona Territorial Governors. The Tubac Presidio is a historical museum 45 miles south of Tucson which bridges 280 years of a period of Spanish and Mexican influence. The grounds include the ruins of a Spanish military post reported to have been built around 1752. Picacho Peak State Park, 35 miles northwest of Tucson on Interstate 10, is managed for hiking, camping, nature study, and relaxation. The park is near the site of Arizona's only Civil War battle.

Lake Patagonia is located 16 miles northeast of Nogales on State Highway 82 and has much to offer in the way of swimming, boating, sailing and fishing.

1/ Bureau of Land Management reports - 1970, 1971, 1973.

Other

The total private and semi-private area used for recreation in the study area is about 5,700 acres. This number includes the 5,670 acres located adjacent to the Aravaipa Canyon Primitive Area and owned by the Defenders of Wildlife (DOW). The remaining areas are located at Kitt Peak Observatory on the Papago Indian Reservation; San Xavier del Bac Mission on the San Xavier Indian Reservation; OK Corral, Wells Fargo, Rose Tree Inn, and Boot Hill Cemetery at Tombstone; Colossal Cave, Old Tucson, and Arizona Sonoran Desert Museum near Tucson; and the Lavender Pit observation point at Bisbee. With the exception of the DOW land, the areas are very small, but these sites serve a recreation need and are visited by many people.

Open and Green Space

Open and green spaces, as defined for this report, are essentially undeveloped, visually attractive natural areas strategically located where most needed to ameliorate intensifying urbanization patterns. To further clarify this definition, certain terms need to be defined. Undeveloped space is land, water, or air which has little or no constructional development such as buildings or other structures. Natural areas are those which have not been altered to the extent of losing most of their essential characteristics. A flood plain which has been cleared of riparian vegetation or a wetland which has been drained or filled is no longer natural. This does not mean that natural areas cannot be used by humans but, rather, that use be limited to those activities which do not diminish the quality and functions of the area. The phrase "to ameliorate intensifying urbanization patterns" is interpreted to limit this need to the larger, faster growing cities.

The Tucson area is the only urban center in the study area which is presently large enough to have open and green space problems. Other towns and cities may have areas which should be preserved as open and green space, but these were not considered since they are of such size that open space is readily available. None had populations which exceeded 15,000 persons. Presently, the city of Tucson has about 25,000 acres in a natural state which could be designated as open space. These areas are located along the stream courses of the Santa Cruz River, Canada Del Oro, Rillito Creek, Pantano Wash, and Sabino Canyon. These lands are least suitable for urban development because of the flood hazard.

Military

Fort Huachuca, located in southwestern Cochise County, and Davis-Monthan Air Force, just outside Tucson, are large military bases. In addition, they use extensive undeveloped areas to test equipment and weapons, to give gunnery and bombing training to personnel, and for ordinance depots. These lands were selected by the military for such uses because they are isolated from developed areas, and there are low demands for other uses. The bombing and gunnery ranges are currently inactive, but the military encourages other uses when consistent with

the basic mission of the facility and safety of the user. Other uses include wildlife management and recreation. The Willcox Playa is used as a bombing range and for aerial photography experiments. Table 4.6 shows the acreage of military land by county and area.

Mineral Production

The total land in the Santa Cruz-San Pedro River Basin used for mineral production in 1970 is estimated to be about 41,400 acres, which is only about 0.4 percent of the study area (Vegetation, Cropland, Urban, and Mining Areas Map, back of report.) Included are surface areas used for mines, mills, smelters, tailings, ponds, waste dumps, and access roads. Surface areas of former subsurface mines and land owned, leased or temporarily occupied for exploration are not included. About 60 percent of this area is in Pima County and occurs mostly east and northeast of the Sierrita Mountains, in the Silver Bell Mountains, and on the southwest side of the Slate Mountains. Thirty percent is in Pinal County, lying mostly on the west side of the Slate Mountains, on the east side of the Vekol Mountains, and in the San Manuel-Mammoth area; and about 10 percent is in Cochise County, primarily in the Bisbee Area.

The nature and intensity of use in the mining areas is such that there is little compatibility with other uses of these lands during the period of operation. Existing laws provide rights to holders of valid mineral claims to use any of the surface necessary for exploration and development of the claim. As a result, it is difficult for land managing agencies to control environmental impacts. However, federal lands in the wilderness system will be closed to extraction of minerals after December 31, 1983. Also, relatively small acreages administered by the Forest Service and the Bureau of Land Management have been withdrawn from mineral entry because of recreation, research, watershed protection, public use, scenic, and environmental values.

Designated Fish and Wildlife

Designated fish and wildlife areas are those which are managed by Federal and State agencies. Data pertaining to name of area, county, managing agency, and size are exhibited in Table 4.7.

Transportation and Utilities

Development for transportation and utilities, has, in general, kept pace with the demands of industry and an increasing population. Interstate highways serve the study area in both a north-south and an east-west direction. The interstate highways, plus a growing system of U.S. Highways and 16 State Highways, provide ready access to the city of Tucson and the larger towns. Many of the smaller communities are served by gravelled roads, but in some cases by only graded roads. The major access roads on the Indian Reservation are paved, but the roads to the individual villages are unimproved. Roads within irrigated cropland areas are adequate, with most section lines being open. Adequate all-weather roads exist on national forests for recreation use and management.

TABLE 4.6

LAND USED FOR MILITARY PURPOSES, 1970

SANTA CRUZ-SAN PEDRO RIVER BASINS

(ACRES)

Area	County						Total
	Cochise	Graham	Maricopa	Pima	Pinal	Santa Cruz	
Upper Santa Cruz	-	-	-	18,177	-	-	18,177
Lower Santa Cruz	-	-	43,140	-	-	-	43,140
San Pedro	80,259	-	-	-	-	-	80,259
Willcox Playa	27,520	-	-	-	-	-	27,520
Whitewater Draw	-	-	-	-	-	-	-
TOTAL	107,779	-	43,140	18,177	-	-	169,096

TABLE 4.7

LOCATION, MANAGING AREA,
AND SIZE OF DESIGNATED FISH AND WILDLIFE AREAS,

SANTA CRUZ-SAN PEDRO RIVER BASINS

Name	County	Agency Managing Area 1/	Primary Purpose	Size 2/ (Acres)
Pena Blanca				
Lake	Santa Cruz	AGF	Fish	45
Waterfowl management area	Santa Cruz	AGF-FS	Waterfowl	50
Parker Canyon				
Lake	Cochise	AGF	Fish	125
Waterfowl management area	Cochise	AGF-FS	Waterfowl	182
Rose Canyon Lake	Pima	AGF	Fish	7
Rucker Canyon Lake	Cochise	AGF	Fish	3
May Memorial Refuge				
Wildlife management area	Cochise	AGF	Deer	560
Manhattan Claims Wildlife Management Area	Cochise	AGF	Deer	531
Willcox Playa	Cochise	AGF	Waterfowl	480

1/ AGF - Arizona Game and Fish Department; FS - Forest Service

2/ Includes land and water

In the more remote areas of the study area, access is generally by jeep, horseback, or on foot.

Bus service is provided by the two major companies to communities along the major routes. Four smaller buslines provide within-state transportation between communities where the demand for this service has developed. Truck service is provided for all communities, both for interstate and within-state hauling. One transcontinental railroad, the Southern Pacific, serves the study area along the same general route as the interstate highways. Southern Pacific Railroad also has a track from Phoenix to the mining communities of Hayden and Winkelman. An interstate line, the San Manuel Railroad, connects with Southern Pacific at this point and serves the mining towns of Mammoth and San Manuel.

Four international airports serve the area. These are located at Tucson, Bisbee, Douglas, and Nogales. In addition, there are ten municipal airports. Eight major airlines serve the Tucson International Airport daily, with both air freight and air express facilities in addition to passenger service. Cochise Airlines, an interstate airline, serves Tucson, Bisbee, Douglas, and Sierra Vista.

Utility services are provided in nearly all areas but are not always adequate. All communities use ground water for municipal and industrial water supply. Tucson has the distinction of being one of the largest cities in the nation that is served entirely by ground water. Many types of ownership are involved in the water supply systems - including investor, municipal, co-op, state, and county. In the smaller communities and on individual farms and ranches, private wells take care of the water needs. There are still many homes, especially on Indian reservations, that do not have inside plumbing.

Sewage and waste water treatment systems range from the most modern to virtually none. Stabilization lagoons are the basic form of waste water treatment facility. In the smaller communities and on many individual farms and ranches and many homes, particularly in smaller communities, leach fields are utilized for sewage disposal. Where there are no inside toilet facilities, pit privies are still in use.

The larger communities have solid waste pickup and disposal, using either sanitary land fills or dumps. Many smaller communities have no such facilities. When this service is not provided, the result is obvious in the amount of trash strewn throughout the immediate area.

Electric, telephone, and gas services are available for larger communities. The majority of these services are provided by major companies such as Arizona Public Service and Mountain Bell Telephone. Where the major companies have not provided services, local companies have been developed.

WATER USE

The water used in the Santa Cruz-San Pedro River Basins is obtained from both surface and ground water supplies. The surface water supply, however, accounts for less than 12 percent of the total withdrawals within the basin; and the economy of the basin is dependent upon its ground water reserves. In this arid region, the use of ground water as a supply is a depletion-type of operation - that is, drawing on a stored, almost fixed quantity rather than the utilization of a renewable resource. The stored quantity may be developed at any rate, but the total quantity available is limited.

As used in this report, the term depletion is defined as the quantity of water consumptively required in vegetative growth, food processing, industrial processes, or in other ways removed from available water supply. Withdrawal requirement is defined as the total quantity of water required under present or projected efficiencies to satisfy the depletion requirement.

Table 4.8 summarizes, by county, the depletions and withdrawals of water for the various water-oriented activities in the Santa Cruz-San Pedro Basins.

Estimates relating to agricultural use were based on reported withdrawals in cases where such data were available. Where actual water data were not available, estimated water withdrawals and depletions were based on cropped acreages and estimated unit crop water requirements derived from research conducted by the universities and federal agencies.

Consumptive use by irrigated crops amounts to nearly 88 percent of the total depletions related to man's activities. The total acres irrigated for crop production in 1970 amounted to 396,900 acres of which over 87 percent were irrigated using ground water reserves. Normalized 1970 surface water diversions were estimated to be 212,000 acre-feet, or less than 12 percent of the total irrigation supply. An additional 1,582,800 acre-feet of water was pumped for irrigation.

Certain amounts of water withdrawn for irrigation return to the ground water reservoir and subsequently become available for reuse. Recharge coefficients for irrigation return flows have been estimated to range from zero to 55 percent of the applied water. 1/ The total amount of water returning to the ground water reservoir in this manner, under normalized 1970 conditions, is estimated to be in excess of 540,000 acre-feet or about 30 percent of the total irrigation in the study area.

1/ Estimated recharge coefficients are based on data developed during ground water model studies by the Arizona Water Commission and the Soil Conservation Service.

TABLE 4.8

ESTIMATED WITHDRAWAL AND DEPLETION WATER REQUIREMENTS BY COUNTY

NORMALIZED 1970 LEVEL OF DEVELOPMENT

SANTA CRUZ-SAN PEDRO RIVER BASINS

UNITS: 1,000 Acre-Feet

County	Irrigated Agriculture		Municipal and Industrial						Total	
			Mineral Industry		Steam Elec. Power		Other M & I 1/			
	Withd.	Deple.	Withd.	Deple.	Withd.	Deple.	Withd.	Deple.	Withd.	Deple.
Cochise	373.1	246.9	8.8	8.2	1.1	1.1	12.1	8.7	395.1	264.9
Graham	61.8	41.7	-	-	-	-	0.1	0.1	61.9	41.8
Maricopa	-	-	-	-	-	-	-	-	-	-
Pima	273.5	212.0	46.3	45.1	6.1	6.1	76.9	68.5	402.8	331.7
Pinal	1070.0	718.0	23.6 2/	23.0 2/	1.4	1.4	13.4	10.3	1108.4	752.7
Santa Cruz	16.4	10.5	0.2	0.2	-	-	2.4	1.8	19.0	12.5
TOTAL	1794.8	1229.1	78.9	76.5	8.6	8.6	104.9	89.4	1987.2	1402.6

1/ Includes livestock consumptive use, except stock pond evaporation.

2/ Includes 10,000 acre-feet of ground water pumped in the Lower San Pedro Basin and exported to Gila River Basin.

Water withdrawal and depletion requirements for the mineral resource section, as shown in Table 4.8, are 78,900 acre-feet and 76,500 acre-feet, respectively. Copper, lead, and zinc operations account for most of the mineral production in the area. The copper industry, the largest of the three, is the major water user. Minor amounts of water are also used by sand and gravel operations scattered throughout the study area and by the Arizona Portland Cement plant located near Rillito. The estimated depletions for the mineral industry are based on data developed by the Arizona Water Commission in connection with the State Water Plan.

Electric power generating facilities depleted the basin's ground water supply by an estimated 8,600 acre-feet under normalized 1970 conditions (Table 4.8). This use is related to five thermal-steam generating plants located in the study area. Water at steam generating plants is used for four basic purposes:

1. Condenser cooling
2. Boiler use
3. Washing, rinsing, and other maintenance
4. Domestic and landscaping usages

The first use comprises the bulk of the consumptive use (about 90 percent of the total withdrawal). Only minor amounts are required for the other three purposes. The name, type of ownership, location, and rated capacities of the five generating plants are given in Table 4.9.

Water withdrawals for "Other Municipal and Industrial" (M&I) purposes totaled 104,900 acre-feet for the 1970 level of development. Based on an average depletion versus withdrawal ratio of 85 percent, approximately 89,400 acre-feet were depleted in meeting the demands. The M&I segment of depletion considered here includes domestic (both rural and urban), manufacturing, livestock, governmental, commercial, recreational, and other minor related uses.

Domestic uses include laundering, dishwashing, garbage disposal operations, cooking and food preparation, house cleaning, and evaporative cooling as well as personal uses such as toilet flushing, bathing, and drinking. Exterior uses include lawn and plant watering, swimming pool water, and car washing. Domestic uses of water have been increasing as technological advances make water using appliances more available and economically attractive.

Domestic water requirements exhibit definite seasonal variations. Withdrawal requirements vary from a maximum during the summer months, amounting to about 170 percent of the average monthly withdrawal requirement, to a minimum during the winter months of about 40 percent. Peak demands occur primarily during the months of June, July, and August.

Manufacturing water requirements vary significantly among different industries and among manufacturing plants within a particular industry. Manufacturing requires water for a variety of purposes including cooling,

TABLE 4.9

THERMAL-ELECTRIC POWER RESOURCES

SANTA CRUZ-SAN PEDRO RIVER BASINS

December 31, 1965

Utility Name	Type of Ownership	Plant Name	Plant Location	Installed Capacity (KW)
Arizona Public Service	Private	Saguaro	Red Rock, AZ	250,000
Tucson Gas and Electric Co.	Private	Demoss petrie	Tucson, AZ	140,500
"	Private	Irvington	Tucson, AZ	331,236
"	Private	Irvington	Tucson, AZ	173,300
Arizona Electric Power Corp.	Coop.	Apache	Cochise, AZ	75,000

Source: Appendix XIV, Electric Power, Lower Colorado Region Comprehensive Framework Study, Table 7. (44)

steam generation, processing, and sanitary water uses. These requirements are met by withdrawals and by recirculation and reuses. The recirculation ratio (gross water used divided by withdrawals) in the Lower Colorado Region, including the study area, was almost three times as high as the national average in 1964. The high cost of water provides an economic incentive for conservation measures.

Virtually all of the water withdrawn for livestock purposes is depleted by the animals or by evaporation from sanitary disposal lagoons. Major water withdrawals are connected with large commercial feed lots and dairies which are generally concentrated in locations where water and feed grains are plentiful.

Governmental requirements for water result from a wide range of federal, state, and local activities. Some of the government uses include supplies for: public buildings such as post offices, schools, office buildings, and military installations; watering public lawns, parks, and golf courses; and other activities such as fire control, street cleaning, and public swimming pools.

Commercial uses of water are varied and closely approximate the domestic uses of water. They are largely associated with the trade and service industries such as restaurants, service stations, laundries, hotels and motels, grocery and dry goods stores, and department stores.

The 1970 annual withdrawals for municipal and industrial purposes, excluding water for livestock, mineral industry, and steam electric generation, amounted to about 185 gpcd (gals. per capita per day) for the study area. Table 4.10 has been prepared to show the variation of M&I withdrawal rates in Cochise, Pima, Pinal and Santa Cruz Counties.

TABLE 4.10

MUNICIPAL AND INDUSTRIAL WATER WITHDRAWAL RATES BY COUNTY

SANTA CRUZ-SAN PEDRO RIVER BASINS 1/
1970

County	Withdrawal (gpcd)
Cochise	170
Pima	198
Pinal	150
Santa Cruz	144

1/ Does not include water used by livestock, mineral industry, or steam electric generation.

The relatively low per capita use rate in Santa Cruz and Pinal Counties reflects their high percentage of small towns and rural population. A more drastic variation in per capita consumptive use can be seen when comparing individual towns than when comparing summarized county data. Generally speaking, the larger and more progressive the town the larger will be its per capita consumptive use of M&I water. This can be attributed largely to the greater use of water by the industrial and recreational sections in comparison to that used for domestic purposes. The rate of water use in the Tucson area is 200 gpcd as compared to about 100 gpcd for the city of Willcox. The two highest per capita consumptive use rates are found at the two military bases located in the study area. Davis-Monthan Air Force Base, located near Tucson, and Fort Huachuca, in Cochise County, had per capita consumptive use rates of 315 and 448 gallons per day, respectively, in 1970. These high rates result from the large number of visitors and workers who do not live on the bases.

The basin's water supply also is depleted through natural causes. Reservoir and stock pond evaporation losses were estimated for all natural and manmade water bodies. Data on location, number, and size of stock ponds were revised from documented data developed during the Lower Colorado Region Comprehensive Framework Study. Data on location and average surface area of other water bodies within the study area were developed from aerial photographs, quadrangle sheets, and from published studies and reports prepared by other federal, state, and local agencies.

Net evaporation losses (depletion) were determined by subtracting the normal annual precipitation (Figure 1, page 2.2) from the annual rate of lake evaporation (Figure 5, page 2.7). The net annual reservoir evaporation under present conditions was computed to be 27,500 acre-feet. No attempt was made to allocate present evaporation losses to specific functions, although many water bodies have been created or used for only one or two purposes.

The greatest depletion from the study area's gross water supply is evapotranspiration from natural vegetation which, for the most part, is unrelated to man's activities. The extent of this segment of depletion has not been determined and will not be discussed herein.

Summaries similar to those presented in Table 4.8 are given in Table 4.11 by ground water basin, except mineral resources and stream electric power generation water uses have been included under the general heading of Municipal and Industrial Water use. The basins are listed in the table in alphabetical order by category, and can be keyed to Figure 20, page 2.44.

Data for Table 4.11 were developed by the Arizona Water Commission for use in the State Water Plan and were originally combined with data shown in Table 2.9, page 2.62. The general discussion of Table 2.9 with respect to the availability, sufficiency and accuracy of data, and classification of ground water basins into catagories also apply to this table.

TABLE 4.11

ESTIMATED WATER WITHDRAWALS, DEPLETIONS, AND OVERDRAFTS BY GROUND WATER BASIN FOR THE SANTA CRUZ-SAN PEDRO RIVER BASINS 1/

Normalized 1970
UNITS: 1000 Acre-Feet

Basin	Category 2/	USE									Dependable Supply	Overdraft
		Basin Export	Agricultural			Municipal and Industrial			Total			
			With-drawal	Re-charge	Depletion	With-drawal	Re-charge	Depletion	Withdrawal [(1)+(2)+(5)]	Depletion [(1)+(4)+(7)]		
	2/	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(10)-(9)
AVR Avra Valley	I	13.4G	136.3F	27.0	109.3	0.3P	-	0.3	150 F	123	4	-119
DOU Douglas Basin	I	0	103 F	33	70	13 F	2	11 F	116 F	81	17	-64
LSC Lower Santa Cruz Basin	I	0	1102 F	354	748	18 F	3	15	1120 F	763	243	-520
USC Upper Santa Cruz Basin	I	15 G	104 F	32	72	127 F	10	117	246 F	204	71	-133
WIL Willcox Basin	I	0	288 F	93	195	2.0G	-	2	290 F	197	15	-182
ALT Altar Valley	II	0	3.6P	1.0	2.6	0.1P	-	0.1	3.7P	2.7	-	-
ARA Aravaipa Valley	II	0	3.8P	-	2.7	0.1P	-	0.1	3.9P	2.8	-	0
LSP Lower San Pedro	II	10	17.1F	-	10.5	14.9F	0.9	14.0	42 F	34.5	-	0
USP Upper San Pedro	II	6	37.0P	-	19.0	7.0G	2.0	5.0	50.0P	30.0	-	-
SBV San Bernardino Valley	IV	0	-	-	-	-	-	-	-	-	-	0

1/ The letter following the numbers indicates the range of probable accuracy: G is Good with ± 5-15 percent error; F is Fair with ± 15-25 percent error; and P is Poor with greater than 25 percent error. The dashes indicate probable but unknown values; zeros indicate withdrawals probably do not occur or are small with respect to the total withdrawal.

2/ The category designations were developed by the Arizona Water Commission and are defined as follows:
Category I: Sufficient data available to prepare fairly reliable estimates of water balance.
Catagory II: Areas where estimates may be made for total withdrawal. Information largely limited to data on use. Other values shown are based on judgments not supported by detailed data.
Catagory IV: Areas where data is sparse and depletions are believed to be less than 1000 acre-feet.

3/ Dependable supply from column 4 in Table 2 9.

Total withdrawals and depletions in Table 4.11 are shown in columns 8 and 9. Total withdrawal for any basin is the sum of basin export (column 1), agricultural withdrawal (column 2), and municipal and industrial withdrawal (column 5). The basin export quantities are also included in the withdrawal amounts for agriculture or municipal and industrial purposes in the basin of use; hence, basin exports appear as withdrawals in two different ground water basins. Care must be used to avoid double counting when using this table to estimate the total study area withdrawal. 1/ Total basin depletion in Table 4.11 is the sum of basin export (column 1), agricultural depletion (column 4), and municipal and industrial depletion (column 7). As basin export represents a loss of water in the basin where the withdrawal occurs, it must be shown as a depletion for that area. The water is actually used in another basin and is counted as a depletion in that basin. Again, care must be used to avoid double counting in deriving a total study area picture. 1/ An added feature of Table 4.11 is an estimate of overdraft for each of the individual ground water basins. The overdraft is equal to the difference between the total dependable supply as given in column 10, and the total depletion as shown in column 9. Following is a discussion of the effect of this on the depth to water by basin.

Upper Santa Cruz Basin

Through the base year 1970, slightly more than 5.89 million acre-feet of ground water has been withdrawn from the alluvium in the Upper Santa Cruz basin. This water has been used for agriculture, municipal, and industrial purposes. Agriculture is the major user.

The result of this large-scale pumping has been a change in the amount of ground water in storage. This has been reflected in a change in ground water levels. In general, the water levels in the basin are declining. The water level has declined more than 75 feet in several small areas, and from 50 to 75 feet in a large area in the central part of the pumped area (see Water Level Change Map, back of report). In a few places, however, there has been almost no change or a slight rise in the water level. This has occurred in the upper reaches of the Santa Cruz River in Santa Cruz County where irrigated farmland has gone out of production, and the rate of natural recharge now exceeds the discharge rate.

Lower Santa Cruz Basin

The pumping of ground water for irrigation accounts for the largest percent of the discharge from the ground water reservoir of the Lower Santa Cruz basin. In 1970, about 18 percent of the ground water pumped in the state was pumped in the Lower Santa Cruz area. Through 1970, more than 33 million acre-feet of water had been pumped in the basin. The annual rate of withdrawal is greatly in excess of the rate of recharge,

1/ The 10,000 acre-feet exported from the Lower San Pedro Basin is not double counted, because it is exported out of the study area.

(Table 4.11) and water levels have been declining as much as 20 feet per year in places. Since large scale pumping began, the overall water level declines have exceeded 300 feet in parts of the area (Water Level Change Map, back of report). Near Casa Grande there has been very little decline, but near Stanfield water levels have declined as much as 340 feet. Near Eloy, the maximum water level decline has been about 200 feet. The average decline for the total basin has been about 140 feet in areas where pumpage occurs.

Altar and Avra Valleys

Except for underflow out of the basin, the ground water resources of Altar Valley remain basically untapped since the basin is largely undeveloped. In Avra Valley, however, ground water withdrawals have been in excess of recharge (Table 4.11). Through 1970, slightly more than 2.6 million acre-feet of ground water had been pumped from the aquifer in Avra Valley. Ground water withdrawal in excess of recharge has caused lowering of the water table. The average change in water level in Avra Valley has been a decline of more than 70 feet (Water Level Change Map, back of report). The water level decline has been least in the upper end of the valley and greatest in the north-central part and at the north end where the greatest amount of ground water withdrawal has taken place.

Upper and Lower San Pedro Basin

Water levels in the San Pedro River Valley fluctuate seasonally in response to recharge and pumping, but in the last 30 years the net change has been small. In the Sierra Vista-Fort Huachuca area, however, the amount of withdrawal has been in excess of the amount of recharge. In this area, two significant cones of depression have developed. The first cone of depression centers about the Fort Huachuca military post and Sierra Vista well fields and appears to extend for approximately four miles, elongating in a northwest-southeast direction along the mountain front. The cone of depression is about 1.5 miles wide.

The second cone of depression is in the Huachuca City area and extends approximately three miles along the Babocomari River, elongating in a southwest-northeast direction along the river channel. Heavy pumping in Huachuca City has apparently reversed the direction of ground water flow, and ground water that formerly followed the Babocomari River to the northeast is now diverted into the depression cone around the city.

Near the center of the cone of depression in the Fort Huachuca area, water levels have declined an estimated 50 feet, and in the Huachuca City area, water level declines of ten feet have been measured. These declines have occurred over a 30-year period from 1940 to 1970. This period was used in developing the Water Level Change Map, back of report; but due to insufficient data at the time the map is prepared, only the cone of depression in the Fort Huachuca area is shown on the map.

Aravaipa Valley

Only a small amount of ground water development has taken place in Aravaipa Valley. The annual pumpage is not known, but the amount of withdrawal probably does not exceed the amount of natural recharge. Only minor changes have occurred in the regional water table (Water Level Change Map, back of report). Water levels in wells in the shallow alluvium along Aravaipa Creek fluctuate in direct response to recharge from precipitation, flows in the creek, and from pumping. Data are insufficient to determine changes in the deeper water levels in the area.

Willcox Basin

Through 1970, slightly more than 3.77 million acre-feet of ground water has been pumped in the Willcox basin. The ground water reservoir is the water supply for the basin, and the amount of water being withdrawn greatly exceeds the amount of recharge. See Table 4.11, page 4.23 The result is an overall decline of water levels in the basin (Water Level Change Map back of report). Water levels have declined more than 100 feet in a large part of the developed area east of the playa. In places, water levels have declined as much as 150 feet. In the developed area north of Willcox, the water level decline has been a maximum of about 80 feet and has been about 60 feet in a large part of the area. Lesser declines have taken place in areas of more recent development. In the area west and south of the playa, water level declines have been about 40 feet. At the north end of the basin near the Cochise-Graham County line, the average water level decline was only about ten feet until 1963. Expanding development in the area is causing more decline; and from the Spring of 1965 to the Spring of 1970, the average decline was more than 35 feet.

Douglas Basin

Ground water has been pumped in the Douglas basin since 1910. Prior to 1945, however, the amount of annual pumpage probably did not exceed 5,000 acre-feet.

Since 1945, the annual pumpage rate has steadily increased, and large overdrafts have occurred. (See Table 4.11, page 4.23). Through the base year 1970, more than 1.5 million acre-feet of ground water has been withdrawn from the basin's aquifers. The large overdrafts of ground water have resulted in a declining water table and a decrease in the amount of water in storage. Through 1970, water level declines ranged from near zero in the southwestern part of the basin to as much as 60 feet in a small area at the north end of the basin (Water Level Change Map). As much as 50 feet of the decline has taken place in a large area in the central part of the basin. Most of the decline has taken place since 1952.

WATER LAW

Surface Water

Long before Arizona became a state, the territorial courts had held, in effect, that the common law doctrine of riparian water rights did not apply in Arizona and that the doctrine of prior appropriation applied to

surface waters. The basis of these court decisions are found in the principle that the federal government has the right to make all laws in any territory of the United States. In the West, early miners diverted water long distances to their mines; and local practice recognized these water uses as superior water rights. The United States formally established the recognition of this type of right in the Mining Act of 1866, (14 Stat. 251 R.S. 2339, 30 U.S.C., Sec. 51). Congress reaffirmed the doctrine of prior appropriation by the 1866 Act and Desert Land Act of 1877. The Water Rights Registration Act now requires registration of these early appropriated rights. In 1893, the Arizona territorial legislature prescribed that any person desiring to appropriate water must post notice at the point of diversion showing the amount of water appropriated and stating the character of the works to be constructed. The territorial legislature further required that such works be completed within a reasonable time.

The Arizona Constitution provided specifically that the common law doctrine of riparian water rights shall not obtain or be of any force or effect in Arizona. Hence, when Arizona became a state, the basic water rights of the area were continued.

In 1919, the Arizona Water Code was adopted. Among other things, this code prescribed procedures for the acquisition of surface water rights. The authority for administration of the Arizona Water Code originally was placed with a water commissioner, but has since been vested in the office of the State Land Department. This code has been amended many times and has been tested and interpreted by the courts, resulting in the establishment of numerous precedents.

Historically, the concept of waters being vested with a character of public property and being subject to appropriation appears to have been the prime factor upon which present Arizona water law is based. The doctrine of prior appropriation, as it is commonly known, bases the right to the use of water upon the application of that water to some reasonable and beneficial purpose regardless of the location of the land.

Water rights applicable to stream water do not in any way depend on ownership of land bordering on a stream or land through which a stream may run. Because valid water rights depend solely upon use, the water may be transported to land or to an area far removed from a stream for this use - even into an entirely different watershed.

The right to stream water or surface water also depends on the time at which the water was diverted for its beneficial purpose. A water right is valid only when it does not interfere with, or damage, the right of another who has a prior claim to the same water source. He who first diverts water for beneficial use has the better right, and other rights of subsequent appropriators are subject to the satisfaction of the earlier right. In case of a shortage of water, the most recent appropriators are required to relinquish their water to the prior appropriators in order that the latter's claim may be fully satisfied. The maxim "first in time, first in right" is an accurate translation of this doctrine.

One has a right only to that amount of water that can and is being used beneficially. The intent of this doctrine that all water is to be used and none is to be wasted is quite clear. There is no intention to maintain the flow of water in the stream. Every available drop can be utilized, even to the extent of drying up the stream itself. If, over a period of time, an appropriator fails to use water to which he has laid claim, he loses his water right; and another may appropriate that water.

The following excerpt is taken from Article I of the Arizona State Water Code: "The water of all sources, flowing in streams, canyons, ravines or other natural channels, or in definite underground channels, whether ponds and springs on the surface, belongs to the public, and is subject to appropriation and beneficial use,.... Beneficial use shall be the basis, measure, and limit to the use of water. Whenever the owner of a right to the use of water shall cease or fail to use the water appropriated for five (5) successive years, the right to the use shall cease; and the water shall revert to the public and be again subject to appropriation."

The Arizona Revised Statutes pertaining to surface water law were amended in 1962 by Senate Bill 39. This bill listed the rights of the State in appropriation of water. It covers severence and transfer of water rights appurtenant to cropland for municipal, stock watering, power, mining, and recreation and wildlife purposes (including fish) under specified conditions and limitations. Consent and approval by all interested parties must be agreed upon before any transfer of water rights may be approved.

Another amendment enacted under Senate Bill 39 during 1962, reads as follows: "As between two or more pending conflicting applications for the use of water from a given water supply, when the capacity of the supply is not sufficient for all applications, preference shall be given by the Department according to the relative values to the public of the proposed use.

The relative values to the public for the purposes of this section shall be:

1. Domestic and municipal uses. (Domestic uses shall include gardens not exceeding one-half acre to each family.)

2. Irrigation and stock watering.

3. Power and mining uses

4. Recreation and wildlife, including fish."

Ground Water

Dating from early territorial court opinions, Arizona courts have repeatedly stated that percolating water (ground waters) belong to the surface landowner and may not be appropriated; and furthermore, that ground water is subject only to reasonable and beneficial use by the landowner; thus, the foundation of Arizona's ground water law was established from court precedents and is based on the distinction that "waters percolating generally through the soil beneath the surface are the property of the owner of the soil" and "subterranean streams, flowing in natural channels, between well-defined banks, are subject to appropriation under the same rule as surface streams." (8 AZ 353)

With reference to the appropriation of water flowing in "subterranean streams," the courts have been inclined to view all underground waters as percolating waters subject to private ownership. The burden of proof that water beneath the surface of the earth is flowing in a definite underground channel rests with the person who is seeking an appropriation of such water.

Because of concern over increasing ground water pumpage in Arizona during the 1920's and 1930's, the Legislature, in 1939, directed the State Land Commissioner to gather information needed for future ground water legislation. In 1945, the Legislature passed the Ground Water Act, which required owners and operators to report, to the State Land Commissioner, data pertaining to their wells and notice of intent before drilling new wells. Although the Act did make the first attempt to provide information about the rate of ground water depletion, it did nothing to lessen or control the excess pumping.

On April 1, 1948, the Arizona Legislature enacted the first Ground Water Code (Sections 45-301 through 324, Arizona Revised Statutes). The code reaffirmed the law with respect to the ownership of ground water and the rules of reasonable use, and designated certain rules and regulations for administration of ground water development.

A very important accomplishment of the code was the establishment of procedures for the designation of critical ground water areas. A "critical ground water area" is defined in Section 45-301 as any ground water basin or any designated subdivision thereof, not having sufficient ground water to provide a reasonably safe supply for irrigation of the cultivated lands in the basin at the then current rates of withdrawal. The code further provides that no permit shall be issued for the construction of an irrigation well within any critical ground water area for the irrigation of lands which on the date the area was declared critical were not irrigated, or had not been cultivated within the five years prior thereto. The code does not provide, however, for control of the extent of pumpage or apportionment of the pumpage among the landowners within the designated critical ground water areas.

Since the enactment of the Ground Water Code in 1948, ten critical ground water areas in Arizona have been designated by the State Land

Department, of which six are located wholly or in part in the Santa Cruz-San Pedro study area. These six areas are shown on the Critical Ground Water Areas and Irrigated Lands Map, back of report and are listed as follows:

Eloy Critical Area
Gila-Santa Cruz Critical Area
Marana Critical Area
Tucson Critical Area
Sahuarita-Continental Critical Area
Douglas Basin Critical Area

Several court cases have upheld the designation of critical ground water areas and clarified the conditions under which ground water may be pumped and used in these areas. The 1955 decision in Southwest Engineering Co. v. Ernst upheld both the principles and the authority necessary to administer the code. This case held that the code was a valid conservation measure enacted by the State Legislature. The code's primary purpose is to regulate irrigation development and to curtail further uses of water for irrigation in critical areas in an attempt to slow down the exhaustion of ground water. The code does not regulate the use of ground water outside of critical areas, with the exception that wastes as defined is universally prohibited.

A recent case, Jarvis v. State Land Department, 1969, involved the transfer and transportation of ground water from wells in Avra and Altar valleys to the city of Tucson. The farmers of Avra Valley petitioned for a writ of injunction requiring the State Land Department to cancel rights-of-way previously granted to Tucson for the purpose of transporting the water. They claimed that such transfer of water from within a critical ground water area would impair the supply available to landowners within the critical area. The Supreme Court of Arizona found for the petitioning farmers and directed that a mandatory injunction be issued for the cancellation of the rights-of-way, in effect, stopping the transportation of water out of the critical ground water area to the city of Tucson. During the case, the city of Tucson had raised the question of eminent domain. On this question, the Court held that condemnation and compensation must come before the taking of private property by one holding this power. This was later to become known as the Jarvis I Decision.

In the months subsequent to the issuance of the injunction, Tucson continued to supply water from its Avra Valley wells to customers both within and beyond the Marana Critical Ground Water Area, but located within the Avra Valley drainage basin. As a result, the original petitioners filed a new petition asking for an order to show cause why the injunction had not been strictly enforced and requesting specifically that Tucson not be allowed to "...transport...ground water from...the Marana Critical Ground Water Area to other areas outside thereof."

In the second decision of this case, now known as Jarvis II, the Court handed down a written opinion of the specific petitioned issues involved which provided: (1) That Tucson would not be prohibited from

delivering water from wells within the designated critical area to localities also within the same designated area; (2) that the city of Tucson would have the burden of proof in establishing that its customers outside the critical ground water area, but within the Avra Valley drainage basin, were located above the common ground water basin so as to be entitled to withdraw water from it; (3) that Tucson could purchase or acquire the title to lands within Avra Valley which were currently cultivated and then use the water which would have been used in the irrigation of such lands as a source of supply for its municipal customers; and (4) that after the acquisition of such lands, Tucson might withdraw an amount of water equal to the historical annual maximum use upon the lands so acquired.

Decrees

The only major decree in effect within the study area is the Globe Equity No. 59, commonly referred to as the Gila Decree. This decree came about because of the efforts of the United States to protect the water rights of the Gila River Indian Reservation lands which were to be a part of the proposed San Carlos Irrigation Project. Parties to the suit included water users and canal companies, both above and below the San Carlos Reservoir. The decree was entered into by stipulation and was adopted June 29, 1935.

The decree awarded an immemorial right to the use of water from the Gila River for 35,000 acres on the Gila River Indian Reservation on the basis of their early irrigation activities, and water rights for an additional 15,546 acres with a priority date of 1924. Non-Indian lands in the San Carlos Project area were granted rights for 50,000 acres of land with varying priority dates. The majority of the 100,546 acres within the San Carlos Project are located south of the Gila River within the Santa Cruz-San Pedro study area.

CHAPTER 5

WATER AND RELATED LAND RESOURCE PROBLEMS AND NEEDS

FLOODING

General

Although rainfall in the study area is meager, and individual storms are generally limited in areal extent, severe flooding can and does occur. Many floods in this desert region have been documented well back into the period of Spanish exploration and settlement. In spite of the scarcity of rainfall, desert conditions are highly conducive to flooding. The sparse vegetation does little to impede runoff and promote infiltration. For this reason, runoff frequently exceeds the infiltration rate and reaches flood proportions. This is especially true with summer thunderstorms.

Due to sparse population in desert regions, many of the past floods developed, raged, and dissipated almost unnoticed. Although this can still happen, the likelihood is decreasing as population and development increase. The growth in population in the desert lowlands during the past three decades has been phenomenal. The development of ground water irrigation has transformed large areas of alluvial valleys into productive agricultural land. Residential and urban developments have been built on flood plains and are subject to inundation. Some of these areas experience frequent floodflows.

Types of Floods and Areas Effected

Most of the flood plains in the study area have been categorized as either (1) riverine or (2) alluvial fan and bottomland flood-prone areas. The Generalized Flood Prone Areas Map shows general location of each type of flooding but should not be used to identify a specific area as being flood-prone. This is especially true of areas designated as alluvial fan flood plains.

The riverine flood plains, shown in red on the map, are those areas subject to inundation by overflow from defined channels. The total area subject to inundation by riverine type flooding has been estimated at 803,200 acres or 7.6 percent of the study area. These flood-prone areas are generally well defined and are usually limited in width by natural terraces which parallel the stream on either side. The terraces are remnants of older flood plains.

Canada del Oro and Rillito Creek are tributaries of the Santa Cruz River and have typical riverine flooding. Streamflow is negligible in these streams except during and immediately after rains. Because of steep gradients, streamflow in the mountains increases rapidly in response to high intensity precipitation and causes debris-laden flash floods to debauch onto the valley plains below. When a flood reaches the valley plains, it spreads out overland but is generally confined to a relatively

narrow overflow area.

Flooding along the San Pedro River is also riverine. Due to the entrenchment of the river over past decades, flows of relatively large magnitude must occur before overbank flooding is experienced. Although this situation limits flooding along the main stem, many tributaries are not as deeply entrenched; and flooding occurs more frequently.

In some locations, however, boundaries of riverine flows are not well defined. This is true of the reaches of the Santa Cruz River downstream from Cortaro. The river and its major tributaries, Brawley Wash, Aguire Valley, and Santa Rosa Wash have broad alluvial flood plains and channels of limited capacity. When flood discharges exceed the channel capacities, floodwaters spread in many directions. The extent of such spreading depends on the magnitude of the flood and on the location of natural or manmade obstructions such as levees. Because overbank flows are usually shallow, low levees provide some protection to areas inclosed by them. Even during the passage of floods of large magnitude, large areas remain protected although surrounded by water on all sides. Should the levees break, such areas would be inundated.

There are also several small natural islands scattered throughout the designated riverine area that are not subject to flooding under normal circumstances. These islands have been formed from past deposition and erosion. They are not subject to inundation unless flow is constricted by manmade improvements such as roads, railroads, and levees which cause increased flood depths. These islands may stand only a few feet above the surrounding area; but due to the shallow overbank flows, they remain above flood stage.

Flooding conditions on alluvial fans and bottomlands (alluvial plains) are similar to those described for the lower reaches of riverine flood plains on the Santa Cruz River. The flood depths are normally shallow and the direction of flow is unpredictable. Alluvial fans are formed in such a way that it is impossible to predict the exact path of any given flow. Much research has been done on the geologic formation of fans, but the hydraulics of fan flooding are not easily understood. Mr. Chester B. Beaty (45) defines the area of greatest flood danger on a desert alluvial fan as a radial zone extending from the apex toward the margin and flanking and including the active channel. The most dangerous part of this flood zone is the active channel itself, together with the strip of land which lies immediately adjacent to it. This danger zone extends downslope below the point at which shallowing of the active channel occurs.

The radial pattern of most alluvial fans insures that debris and water spilling out of the active channel during floods will follow divergent paths and, thus, lose part of their momentum and potentially destructive energy. This spreading creates a sheet flow appearance with shallow depths. For this reason and because of the limited source of floodwaters, the flood hazard on fans is generally less than that experienced on most riverine flood plains.

Mr. Beaty has stated, "A direct correlation exists between the steepness of fan slopes and danger of major floods from the canyon above the fan; thus, steep fans are a first, easily recognizable indication of the possibility of serious floods, while more gently fans suggest a lower flooding hazard." Such characteristics have been indicated to some extent on the Generalized Flood-Prone Areas Map by dividing the alluvial fans and bottom lands according to the steepness of their slopes. Although the severity of flooding is generally greatest on the steeper fans, a much larger percentage of the more gentle slopes will be inundated during the occurrence of any particular flood. This is due to the spreading process and the lack of well defined channels on the more gentle slopes. The flood hazard on bottom lands is generally limited to shallow sheet flow or ponding.

A large percent of the area subject to sheet flow and ponding is located in the reaches of the Santa Cruz River Basin downstream from Tucson. Most of the remaining sheet flow area is located in the Willcox-Playa-Whitewater Draw area. Only a minor part of the San Pedro River Basin has been classified as being subject to sheet flow flooding.

The alluvial fan and bottom land flood-prone areas account for a much larger percentage of the total basin than that of the riverine flood plain. About 3,022,600 acres or 28.6 percent of the study area have been classified in this category. Although the total area designated as alluvial fan and bottom lands is flood-prone, only a small part of the area would be flooded by any one flood. It has been estimated that about 1,135,400 acres of alluvial fan or 10.8 percent of the total area would be inundated at least once in 100 years.

Physical and Monetary Effects

Floodwater can cause severe damages to improvements which lie in its path. This has been illustrated to some extent in the preceding discussion on the Types of Floods and the Areas Effected. Floods in the study area are normally caused by one of three types of storms: summer thunderstorms, winter frontal storms, or tropical storms. A description of each of these storm types is given under Precipitation in Chapter 2.

Of the three storm types, summer thunderstorms normally cause the greatest flood frequency and danger on most alluvial fans. These storms are normally of high intensity and short duration. They cause a rapid build-up of streamflow in the mountainous regions and send violent rushes of floodwaters onto the alluvial plains below. These waters cause extensive damage to houses, roads, farmlands, and other properties.

Winter storms are generally less intense and of longer duration than summer thunderstorms. They can, however, cause rather large flood flows, especially when they occur in conjunction with snowmelt runoff. A storm of this type occurred on December 19-20, 1967 in the upper reaches of the Santa Cruz River. This flood caused considerable erosion and washed out several sections of the Southern Pacific Railroad which parallels the river on its east side. Several footbridges and many grade-level crossings on farm and county roads were also destroyed. The flood eroded large sections of farmland next to the river channel and inundated cropland. One

person was killed while trying to ford Canada del Oro at Tucson.

Tropical storms generally are the largest and most severe of the three types of storms. Tropical storm "Claudia" which moved over the Organ Pipe Cactus National Monument on September 24-25, 1962 is an example of this type of storm. A heavy band of rainfall about 70 miles wide extended from the west side of the study area across Santa Rosa Wash and Brawley Wash into the Canada del Oro drainage basin. The following general description of the flood was taken from "Desert Floods" by D. D. Lewis. (46)

"As the storm developed in Tucson, large areas of impermeable streets and roof surfaces allowed a high percentage of the rainfall to become runoff. The runoff quietly flooded streets and disrupted traffic. Roads, culverts, and bridges were damaged. A few vehicles, trapped by the floodwaters, were swept downstream and destroyed.

Wide overflows from Santa Rosa and Brawley washes occurred because the channels are poorly defined and lack the capacity to handle the floodwaters. Extensive damages were sustained on agricultural lands as dikes were overtopped and breached. Severe flooding also occurred along Blanco and Los Robles washes.

The converging flows of Santa Rosa Wash, Green's Wash, and Brawley Wash created a confused hydrologic picture. Areas as wide as ten miles were inundated and agricultural damages were very high."

The preceding discussion illustrates the types and physical effects of the floods that can occur in the study area. These and similar floods were evaluated with respect to their monetary effects. This was accomplished by first classifying the flood damages into two major categories - agricultural and non-agricultural damages.

Agricultural Damage

The majority of the floodwater damages to agriculture caused by inundation, sediment, and erosion occur in tributaries to the Santa Cruz River and the Gila River Subarea, the drainage area of Willcox Basin, and the Douglas Basin, drained by Whitewater Draw (Table 5.1). The San Pedro Valley sustains relatively little damage to agriculture, and damages in the San Bernardino Valley are negligible, because only small amounts of land are developed in these areas.

Most of the flooding in the prime damage areas is of the alluvial fan and bottom land type. In this type of flooding runoff from the mountains ans steeper fans flows toward the flatter areas, inundating farmlands and improvements. Crop growth is often stunted or disrupted. Although nearly all of the land in the alluvial fans are subject to flooding, only a portion would be inundated from any given flood.

Non-Agricultural Damage

Non-agricultural damages include inundation, erosion, and sediment damages in (1) developed commercial and residential areas, (2) remote

subdivisions (planned and being developed), and (3) other developments such as roads, bridges, utilities, etc. Of the total average annual damages of $1,327,900, about $709,000 (53 percent) occur in the Santa Cruz study area, $410,600 (31 percent) occur in the Douglas Basin, $134,000 (10 percent) in the Willcox Basin, and $74,300 (6 percent) in the San Pedro Basin (Table 5.2). The San Bernardino Valley has no known damages. The dollar damages shown on Tables 5.1 and 5.2 amount to $3,575,400.

TABLE 5.1

AGRICULTURAL

Acres Subject to Flooding and Average Annual Damages Incurred by Sub-Basin, Santa Cruz-San Pedro River Basins 1970

Item	Surface Water Study Area 1/				
	San Pedro Study Area			Santa Cruz	
	Willcox	Douglas	San Pedro	Study Area 3/	Total
		(acres)			
ACRES SUBJECT TO DAMAGES					
Irrigated Acres in Flood Prone Areas	114,600	40,000	5,400	349,350	509,350
Irrigated Acres in Flood Plain Inundated by the 100-year Frequency Storm	62,030	21,350	4,250	186,100	273,730
Average Annual Irrigated Acres Flooded	12,370	4,270	170	37,220	54,030
		(Dollars)			
AVERAGE ANNUAL FLOOD DAMAGES 2/					
Irrigated Land	$292,200	$102,600	$ 5,600	$621,900	$1,022,300
Other Agricultural Improvements	264,700	90,300	7,400	862,800	1,225,200
TOTAL DAMAGES	$556,900	$192,900	$13,000	$1,484,700	$2,247,500

1/ Damages insignificant in San Bernardino Valley.
2/ Includes damages from inundation, erosion, and sediment.
3/ Includes damages occuring in the Gila River Subarea.

Source: River Basin Staff, Soil Conservation Service.

TABLE 5.2

NON-AGRICULTURAL

Acres Subject to Flooding and Average Annual Damages Incurred by Sub-Basin, Santa Cruz-San Pedro River Basins 1970

	Surface Water Study Area 1/				
	San Pedro Study Area			Santa Cruz	
Item	Willcox	Douglas	San Pedro	Study Area 3/	Total
		(acres)			
Developed Residential and Commercial-Acres Existing	350	5,750	1,450	63,500	71,050
Developed in 100-year Flood Plain	250	1,150	50	18,050	19,500
Average Annual Acres Flooded	50	100	-	3,600	3,750
Being Developed in 100-year Flood Plain	15,900	16,300	10,700	162,300	205,200
		(Dollars)			
Average Annual Flood Damages - Developed Residential & Commercial Areas 2/	$ 43,800	$381,100	$60,800	$481,200	$966,900
Remote Subdivisions	14,100	8,600	2,600	7,100	32,400
Subtotal	$ 57,900	$389,700	$63,400	$488,300	$999,300
Other Developments	$ 76,100	$ 20,900	$10,900	$220,700	$328,600
TOTAL	$134,000	$410,600	$74,300	$709,000	$1,327,900

1/ Damages insignificant in San Bernardino Valley.
2/ Includes damages from inundation, erosion, and sediment.
3/ Includes damages occuring in the Gila River Subarea.

Source: River Basin Staff, Soil Conservation Service.

Photograph 17
Lettuce on the section of field inundated was a complete loss. A section of the dike (foreground) broke, allowing floodwater to enter the field. Notice how flow over the irrigation ditch has washed away part of the berm.
(SCS Photograph)

Photograph 18
Flooding of cotton in a more mature stage of growth. Although yield reductions occur from floods such as this, the effect is not as drastic as on the lettuce shown above.
(SCS Photograph)

Photograph 19
Flood damage to a concrete lined irrigation ditch (Whitewater Draw) *(SCS Photograph)*

Photograph 20
Floodwater completely destroyed sections of this dike. Lettuce crop in foreground was severely damaged. *(SCS Photograph)*

Photograph 21
Fence damage and scour caused by floodwater. *(SCS Photo)*

Photograph 22
Flooding of irrigation well leads to foundation problems (McClellon Wash) *(SCS Photograph)*

Photograph 23
Flooded streets prevent residents from leaving or returning to their homes. (Casa Grande) *(SCS Photograph)*

Photograph 24
Costly cleanup, repairs, and replacement of damaged items to follow the receding floodwater.
(Tucson Daily Citizen Photograph)

Photograph 25
Floodwater damage to businesses in Tucson on August 20, 1959.
(Tucson Daily Citizen Photograph)

Photograph 26
Washout of bridge in Altar Valley.
(SCS Photograph)

Photograph 27
Railroad laborers trying to keep bridge abutments from washing out (Eloy) *(SCS Photograph)*

Photograph 28
The Santa Cruz River washed out bridge abutment on Ajo Road in Tucson on August 22, 1961. *(Tucson Daily Citizen Photograph)*

EROSION AND SEDIMENT

The term erosion is defined as the detachment of soil and rock particles by water, wind, ice, or gravity. Sediment is the by-product of erosion and is defined as solid material that has been detached from its place of origin and is being transported or has been deposited. Throughout geologic time, the erosive forces of water have been carving the earth's surface. Water erosion is largely responsible for present-day topographic features. The accumulation of thousands of feet of sediment in the broad valleys of the study area is evidence of the tremendous volumes of materials which have been removed from the mountains by erosion.

Both man and nature have tremendous impacts on the cyclic patterns of the erosion process. In an area of delicate balance, a condition of relatively mild erosion can be easily upset by geologic events, by climatic conditions, or by man's misuse of the land and vegetation. The results can be a severe erosion cycle, especially where a combination of the above causes is involved. In such a case, man may be hard-pressed or even unable to reverse the destructive cycle. In other areas where the balance is less delicate but where erosion has been accelerated, primarily because of man's destruction of cover, erosion can be reduced materially by proper land treatment and management.

Erosion

General

Erosion in the study area ranges from slight to severe. The lower rates are occurring on the forested and well-grassed areas which are usually found in the mountains and on nearly level irrigated cropland. The highest rates are in the deeply incised valley fill. Because of the infrequent occurrence of significant rainfall, the major portion of total erosion during a normal year results from one or two storms. The erosion resulting from an extremely severe storm may exceed the total erosion of many previous or following years.

The most rapid erosion in the study area is taking place in the San Pedro Valley and appears to be largely the result of climatic and geologic conditions. In the not-too-distant geologic past, the individual alluvial valleys of the study area were closed basins. After the Gila River developed through-drainage to the west, the San Pedro River and other tributaries began to establish their courses. There is evidence that rapid cutting into the valley fill occurred during climatic periods which were dominated by high intensity summer rainfall. A climatic period, characterized by gentle winter rains and little erosion, was drawing to a close when cattle ranching began to spread. 1/ The balance between erosion and deposition of valley fill was delicate, and

1/ Pollen studies by Dr. Alfred E. Dittert, Jr. and Dr. James Schoenwetter, archeologists at the Department of Anthropology at Arizona State University, indicate that winter rains were dominant in the Southwest between 1300 and 1850 AD and that summer rains have dominated since about 1850.

a new cycle of erosion could be easily triggered by either natural events or man's activities. A new surge of erosion evidently began in the San Pedro Valley in the late 1800's when the summer rain pattern became more pronounced. Destruction of vegetation caused by overgrazing is often cited as the reason for the increased erosion. The relationship between overgrazing and stream cutting is not clear according to the search of records by Hastings and Turner (47). The impact of overgrazing is not easily separated from geologic erosion. Cover destroying drought conditions and extreme flooding following a long period of quiet streamflow must also be taken into account. It is also possible that minor disturbances of the land surface by seismic activity are related to the erosion cycle.

Presently, the peak of the erosion cycle seems to have passed the lower reaches of the San Pedro Valley. Early signs of stabilization can be seen along the main stem and on some portions of the upland. In the middle and upper reaches, the cycle has yet to reach its peak. Streambank erosion, gullying, and piping are highly active. Aravaipa Creek, a major tributary of the San Pedro River, has its headwaters in the same structural trough which contains the closed Willcox Basin. The ultimate result of continued headward advancement of Aravaipa Creek would be the establishment of through-drainage in the Willcox Basin.

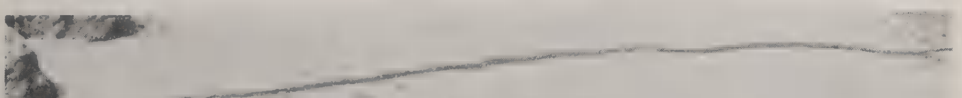
Much of the more severe erosion is occurring on State land. The State Land Department does not have funds for the improvement or treatment of State lands and relies on leasees for funding such work. Legislation is needed to establish a revolving fund which would enable the State Land Department to enter into a program of intensive management and treatment.

Physical Effects

Four types of erosion are recognized in the study area: (1) sheet and rill, (2) stream channel and gully, (3) flood plain scour, and (4) piping. Sheet and rill erosion account for the majority of total erosion, although there are areas where channel erosion is the dominant process. The main factors effecting sheet and rill erosion are vegetative cover; rainfall intensity and frequency; degree and length of slope; texture, organic matter content, and permeability of the soil; and occurrence and geologic makeup of rock outcrops and coarse fragments on the surface. The occurrence of even, very thin gravel and coarse sand on the surface (erosion pavement) is extremely important in a desert environment. Many areas with little or no vegetation, which are subjected to high intensity rainfall, still have low erosion rates because of a protective surface sand and gravel. Such condition is shown in the following photograph.

Stream channel and gully erosion account for substantial portions of total erosion in the San Pedro and Aravaipa valleys and along segments of the Santa Cruz River just south of Tucson, Altar Wash, upper Green's Wash south of Eloy, and a short segment of McClellan's Wash east of Eloy. See the Erosion Classification Map. Less severe but significant channel erosion is occurring along Whitewater Draw, Black Draw,

Photograph 29
Erosion pavement is responsible for low erosion rates on soils with little vegetation. *(SCS Photograph)*



Photograph 30
Large blocks of soil lie on channel bottom following streambank erosion. *(SCS Photograph)*

Greenbush Creek, Babocomari River, Sopori Wash, a segment of the Santa Cruz Wash northwest of Casa Grande, some tributaries of Pantano Wash southeast of Tucson, and Box O and Donnelly washes east of Florence. Except for isolated localities, stream channels in the remaining parts of the study area are relatively stable. Large volumes of coarse grained bedload sediment are typical of steeply sloping desert washes and are necessary in maintaining a state of equilibrium between erosion and deposition.

Land voided by stream channel and gully erosion is, for the most part, unimproved. However, a small amount of gullying does occur on developed areas.

Photograph 31
Severe scouring of channel exposes gas line in Douglas Basin. *(SCS Photograph)*

Floodwaters sweeping across irrigated cropland usually result in scour damage. While this type of erosion accounts for only a slight portion of total erosion, it is highly important monetarily. Scoured areas in cultivated fields must be filled with soil and releveled in order to maintain proper irrigation grades.

Piping is a process of subsurface erosion. Soil material is removed by seepage water flowing through subsurface channels or "pipes". This process is common in the San Pedro Valley alluvial fill. It ultimately becomes part of the gully systems as surface soils collapse into the "pipes".

Five erosion classes are recognized in this report. The location and relative size of each class are shown on the Erosion Classification Map. Class 1 occurs in scattered areas too small to delineate on the map. Where it occurs, it is included within Class 2 delineations. Table 5.3 lists the characteristics and average annual erosion rate for each class. Photographs on pages 5.22 through 5.24 are representative of erosion classes occurring within the study area.

Photograph 32
Damaged section of road is hazardous and costly to repair.
(SCS Photograph)

Photograph 33
Washout of culverts can lead to serious accidents.
(SCS Photograph)

TABLE 5.3

CHARACTERISTICS AND EROSION RATES OF EROSION CLASSES

SANTA CRUZ-SAN PEDRO RIVER BASIN

Class	Characteristics	Average Annual Erosion Rate (Ac. Ft./Sq. Mi.)
1.	Incised valley alluvium: gully erosion predominant over sheet and rill erosion; numerous headcuts; piping common; steep slopes; mostly barren; no protective coarse fragments on surface; silty, saline soils.	>4.50
2	Incised valley alluvium: severe gully erosion; some piping; steep slopes; very sparse vegetation to barren; little or no protective coarse fragments on surface; silty, saline soils.	1.50-4.50

Page 1 of 2 Pages

Table 5.3 (Continued)

Class	Characteristics	Average Annual Erosion Rate (Ac. Ft./Sq. Mi.)
3.	Incised valley alluvium: some active gully erosion; well defined sand bed channels; steep to moderate slopes; sparse desert shrub cover; protective coarse fragments on surface; gravelly soils.	0.75-1.50
4.	(a) High alluvial fan deposits: minor channel erosion; steep gradient channels with coarse bedload; moderate to steep slopes; desert shrub and poor grass cover; well developed protective coarse fragments on surface; gravelly soils.	0.35-0.75
	(b) Low alluvial fan deposits: minor gully erosion; broad, sand filled channels; gentle slopes; desert shrub and poor grass cover; mostly protected by surfaces of coarse sand and fine gravel; medium and fine soils.	
	(c) Arid mountains composed of granite and schist: minor gully erosion; rocky channels; steep slopes; desert shrub and poor grass cover; gravelly, cobbly, and stony soils; substantial area in rock outcrop.	
5.	(a) Nearly level valley floors: little or no gully erosion; poorly defined channels; desert shrub, grassland, or irrigated crop cover; little or no coarse fragments on surface; fine and medium textured soils. The only significant erosion occurs as flood plain scour.	<0.35
	(b) Subhumid mountains: little or no gully erosion; rocky channels; conifer forest, oak woodland, or good grass cover; gravelly, cobbly, and stony soils; substantial area in rock outcrop.	

Source: River Basin Staff, Soil Conservation Service

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Photograph 34
Erosion class 1 along San Pedro River near St. David.
(Forest Service Photograph)

Photograph 35
Erosion class 1 (background) and class 4 (foreground). Areas of class 1 are too small to be shown on the Erosion Classification Map. *(SCS Photograph)*

Photograph 36
Erosion class 3 in San Pedro Valley where erosion pavement protects steep slopes. Class 4 occurs on gently sloping lower areas which are well protected by grass. *(SCS Photograph)*

Photograph 37
Erosion class 2 in San Pedro Valley near St. David. Note lack of erosion pavement on steep slopes. *(SCS Photograph)*

Photograph 38
Erosion class 5 on gently sloping, desert grassland.
(FS Photograph)

Photograph 39
Erosion class 4 on mountain slopes and pediment in Sonoran Desert. *(FS Photographs)*

Table 5.4 shows the area in each class and average annual total erosion by subareas of the Santa Cruz-San Pedro River Basins.

TABLE 5.4

EROSION CLASSES AND AVERAGE ANNUAL TOTAL EROSION

SANTA CRUZ-SAN PEDRO RIVER BASINS 1/

Sub-Area	Erosion Class 2/ (Square Miles) 1	2	3	4	5	Average Annual Total Erosion (Ac.Ft.)	(Ac.Ft./Sq.Mi.)
Whitewater Draw and San Bernardino Valley		0	0	906	670	619	0.39
Willcox Basin		0	0	948	705	648	0.39
San Pedro River	30	270	417	2572	500	4059	1.07
Upper Santa Cruz River		-	121	2339	734	1574	0.49
Lower Santa Cruz River	1	11	113	3079	3085	2440	0.38
TOTAL	31	281	651	9844	5694	9340	

1/ Excludes drainage area in Mexico.
2/ Areas of Class 1 too small to map.

Sediment

General

Most of the streams of the study area transport sediment only during infrequent flows, most of which occur in response to intense summer thunderstorms. Such flows normally contain high concentrations of suspended and bedload sediment. Very large flow events may inflict tremendous sediment damages on lands and improvements. Because of infrequent occurrence and short duration of large flow events, the average annual sediment yield for much of the study area is relatively low.

The few reaches of perennial and intermittent streams are found mainly at high elevations. Because the drainage areas of such reaches are well protected by vegetation or have erosion resistant soils, the flows are predominantly clear. For example, analysis of USGS records on Garden Canyon in the Huachuca Mountains indicates an average sediment yield less than 0.05 acre-feet per square mile.

The San Pedro River is a major exception to general conditions in the study area. Upstream from Charleston, the base flow is normally clear; but floodflows carry moderately high concentrations of sediment.

A maximum daily suspended sediment concentration of 30,600 mg/l was measured at Charleston in July 1966. 1/ Based on a sediment rating-flow duration analysis, the estimated total average annual sediment yield at this point is 0.4 acre-feet per square miles.

Downstream from Charleston, highly active dissection of valley fill is responsible for a higher rate of sediment yield. At Winkelman, just above the confluence with the Gila River, the maximum daily suspended sediment concentration measured by the USGS is 123,000 mg/l; and the estimated total average annual sediment yield is 0.5 acre-feet per square mile. Comparison of the sediment yield at Charleston and at Winkelman does not reflect entirely the difference in erosion rates. Below Charleston, the prevalence of topographic features which induce sediment deposition apparently results in a lower precentage of eroded material being delivered to the river. For example, much sediment is deposited on alluvial fans at the bases of rapidly eroding escarpments. Also, conditions for in-channel deposition are increasingly more favorable as the channel becomes wider and more braided downstream. Finally, no detailed analysis was made of watershed conditions in the Mexico portion of the San Pedro Basin. Of the 1,219 square mile drainage area above Charleston, 696 square miles are in Sonora, Mexico. It appears that the rate of sediment yield from the Mexico portion is considerably greater than the portion between the international boundary and Charleston.

The Santa Cruz River has a well defined channel and efficiently transports its sediment load in the reaches upstream from the Brawley Wash confluence. Downstream, however, the channel gradient becomes progressively flatter; and the channel eventually loses its identity. Flows course in many directions through the irrigated area of western Pinal County. The sediment transport capacity is so greatly diminished that a very small percentage of the sediment which passes the Brawley Wash confluence reaches the Gila River near Picacho Peak, most of the river flow and sediment load are diverted westward into Greens Wash. Much of the diverted sediment is deposited in and just downstream from the diversion channel. The sediment load which is not diverted is deposited mainly in the many channel braids, in irrigation and roadside ditches, on fields, and on large, poorly drained flats.

Surface mining results in waste and tailing dumps which are potential critical sources of sediment if not reclaimed. Reclamation treatment is progressing in some mined areas in the study area. Considerable success has been achieved by the Pima Mining Company in vegetating steep waste dump slopes and reducing erosion south of Tucson. In the Casa Grande vicinity, the American Smelting and Refining Company plans reclamation programs in conjunction with mining operations. The company has hired an agronomist to direct this very important phase of its operations. Abandonment of major mining operations as planned in the Bisbee area by the Phelps-Dodge Corporation, will require considerable treatment to control erosion and sediment yield. Phelps-Dodge is presently making trials of plants and soil amendments for this purpose.

1/ U.S. Geological Survey Measurement.

Physical Effects

The San Pedro River contributes a very large percent of total sediment load of the Gila River at the Ashurst-Hayden Diversion Dam. Nearly all sediment derived from the Gila River watershed upstream from the San Pedro River is deposited in the San Carlos Reservoir. All flows at the Ashurst-Hayden Diversion Dam with the exception of infrequent floodflows are diverted for irrigation of the San Carlos Project. Of the estimated total average annual sediment yield of 5.4 million tons 1/ at the diversion dam, an estimated 3.9 million tons 2/ are derived from the San Pedro River watershed. Large amounts of sediment are removed mechanically from behind the diversion dam and from the canal system. Such removal to keep water flowing at the diversion has cost about $5,000,000 since 1934. A portion of the sediment load is causing rapid depletion of storage capacity in Picacho Reservoir, a small holding reservoir and a habitat for waterfowl. The reservoir has been dredged and rebuilt once to maintain storage capacity.

Sediment accumulations at the heads of reservoirs lead to the establishment of riparian and phreatophyte vegetative stands. The stands act as filters which concentrate sediment deposits. Such conditions can close off low flows into reservoirs as has happened at San Carlos Reservoir. After construction of the proposed Buttes Dam on the Gila River by the Bureau of Reclamation, nearly all the sediment yield from the San Pedro River will be trapped. The San Pedro sediment problem would be transferred to Buttes Reservoir. Costly storage for a large volume of sediment must be provided to avoid encroachment on conservation storage. Also, fish habitat created by the reservoir could be seriously degraded; and the visual quality of the water body will be impaired during periods of heavy inflow. Other reservoirs, including the existing St. Clair and Patagonia Reservoirs and the proposed Charleston Reservoir, have or will require storage for sediment.

The estimated total average annual sediment yield from the study area is 3,800 acre-feet. Of this, it is estimated that 1,260 acre-feet are discharged into the Gila River via Santa Cruz River and minor Gila River tributaries; 1,895 acre-feet are discharged from the San Pedro River into the Gila River, much of which is returned to the study area at Ashurst-Hayden Diversion Dam; 315 acre-feet enters the Republic of Mexico via Whitewater Draw and Black Draw; and 330 acre-feet are deposited in Willcox Playa. Estimates of average annual sediment yield at various locations, including sediment originating in Mexico, are shown in Table 5.5.

1/ Based on flow-duration-sediment rating curve analysis for Gila River at Kelvin (1963-71) by SCS.

2/ Based on flow-duration-sediment rating curve analysis for San Pedro River at Winkelman by SCS.

Photograph 40
Sediment will have to be removed from irrigation ditch before next irrigation. *(SCS Photograph)*

Photograph 41
Workers trying to save peach trees from sediment deposit in Douglas Basin. *(SCS Photographs)*

Photograph 42
Ashurst-Hayden Diversion Dam. Dredge in right background is continuously removing sediment near inlet to Florence-Casa Grande Canal. *(SCS Photograph)*

Photograph 43
Downstream view along Florence-Casa Grande Canal in immediate vicinity of Ashurst-Hayden Diversion Dam. Note sediment (right) which has been dredged from the canal. *(SCS Photograph)*

TABLE 5.5

SEDIMENT YIELD

SANTA CRUZ-SAN PEDRO RIVER BASINS

Location	Average Annual Sediment Yield 1/ (Ac. Ft.)	(Ac. Ft./Sq. Mi.)
Whitewater Draw and Black Draw at the International Boundary 2/	340	0.20 4/
Willcox Playa 3/	330	0.20 4/
San Pedro River at Mouth	2,240	0.50 5/
Santa Cruz River at Mouth	1,240	0.13 4/
Gila River Tributaries between Mouths of the San Pedro and Santa Cruz rivers	160	0.39 4/

1/ Includes estimate of sediment yields from Mexico portions of drainage areas (Whitewater Draw - 109 sq. miles; San Pedro River - 696 sq. miles; Santa Cruz River - 395 sq. miles.

2/ Tributaries of Rio Yaqui in Mexico.

3/ Closed basin. Sediment does not leave study area.

4/ Based on Erosion Classification Map and estimated ratio of sediment yield to total erosion.

5/ Based on SCS analysis of U.S. Geological Survey gage records on San Pedro River at Winkelman.

WATER SHORTAGES

Introduction

There are many criteria by which to measure the adequacy of water supplies to meet demands. In one sense, the total study area could be classified as a water-short area. The renewable water supply has been developed and utilized for many decades. Except for infrequent large floods or exceptional runoff sequence, outflow from the study area is negligible under present conditions. The expanding economy of the area has been supported by the overdraft of ground water, a depletion-type of operation. Overdraft is drawing on a stored, almost fixed, quantity rather than the utilization of a renewable resource. Until another source of water is introduced, or the economic means to better utilize and conserve the present source is adopted, the overdraft will continue. This overdraft is estimated to be over one million acre-feet annually under normalized 1970 conditions. (Table 4.11).

Irrigation

Water requirements for irrigation are supplied both by surface and ground water resources. The current amount of ground water pumped, however, exceeds the amount of surface water diversion several times. The only major use of surface water for irrigation in the study area occurs in the San Carlos Project located in the Florence-Coolidge-Casa Grande area. Minor diversions of surface water from the San Pedro River by the Pomerene Canal, the St. David Irrigation Ditch, and other small ditches are occurring. The San Carlos Project receives most of its surface water from San Carlos Reservoir. Coolidge Dam, which forms the reservoir, was built following a period of above normal runoff. Rainfall of subsequent years has not been adequate to produce the expected runoff. As a result, large acreages in the project remain idle each year. There are approximately 100,000 acres of designated lands within the San Carlos Project - about 50,000 acres in the San Carlos Indian Irrigation Project on the Gila River Indian Reservation and about 50,000 acres of non-Indian land in the San Carlos Irrigation and Drainage District. The non-Indian lands have been fully developed for irrigation; but only about 80 percent, or 40,000 acres, of the designated Indian lands have been developed as of 1974. Project water delivered to designated lands over the life of the project from both surface and ground water sources has been about two acre-feet per acre per year and has varied from one to three acre-feet per acre per year. Assuming a cropping pattern similar to that given in Table 3.7, page 3.15, and an average on-farm efficiency of about 60 percent, a full water supply would be about 5.0 acre-feet per year for each of the designated acres. This amounts to a total of about 500,000 acre-feet annually. Because of large losses in the unlined canals, this would require a total withdrawal (surface and ground water) of about 830,000 acre-feet annually. About 40 percent of the total withdrawal is lost before it reaches the farm headgate. The loss would be 10 to 15 percent with a lined system.

The result of the limited water supply has been that, on the average, about 40 to 50 percent of the designated land lies fallow. Irrigated acreages vary annually, but not necessarily in direct ratio to the water supply. The average acres irrigated for the period 1958-69 were approximately 50,400 acres.

The San Carlos Project has had to supplement its surface water supply through ground water pumping almost from its inception. The same is true in the Pomerene area and the St. David Irrigation District located in the San Pedro River Valley. Flow is intermittent through the stream reach where water is diverted for irrigation. Ground water supplies in the San Pedro River Valley, however, are adequate for the present level of agricultural development. Water levels fluctuate seasonally in response to pumping and recharge. In the last 25 years, the net water level change has been small except in the Sierra Vista-Fort Huachuca area where a cone of depression has developed in response to pumpage for municipal and industrial purposes.

The ground water resources in most of the study area are being utilized faster than they are being replenished. Increased pumping costs associated with large scale ground water declines have resulted in many acres lying idle each year. Only about 60 percent of the total area developed for irrigation in Pinal County is cropped in any one year. Large sections of the study area have been declared critical ground water areas (Critical Ground Water Areas and Irrigated Lands Map). The net effect of the critical ground water designations has been to limit the development of any new irrigated land within an area declared critical, but the law oes allow for the replacement or deepening of an existing irrigation well. The replacement or deepening of an existing well is dependent "upon a satisfactory showing that the well intended to be replaced or deepened will not longer yield sufficient water to irrigate the land normally supplied by it within the five years immediately prior to filing application for the permit." (Section 45-316 of Arizona Revised Statutes)

In some areas, the depth to water has increased to the extent that it is not economical to use ground water for irrigated agriculture. Under present-day technology and economic conditions, about 700 feet is the practical limit for pumping water for agricultural use. This will result in the remaining water being available for M&I use as municipalities, water utility companies, and industry generally have the ability to absorb the cost for deeper and more expensive wells.

Basins (Chapter 2) which contain designated critical ground water areas are the Lower Santa Cruz, Upper Santa Cruz, Avra Valley, Alter Valley, and Douglas. The Willcox ground water basin, although it has not been declared critical, has had an estimated 19,000 irrigated acres withdrawn from crop production. A large portion of this is due to high costs associated with declining water levels. (See the Critical Ground Water Areas and Irrigated Lands Map) In most cases, however, sufficient water could be obtained from existing wells if they were deepened; but present yields of the wells are inadequate to meet irrigation demands because wells have not been improved.

Municipal and Industrial

Water supply development for municipal and industrial (M&I) purposes in the study area is dependent solely on ground water resources and has generally been adequate to meet present level demands. Except for the city of Nogales there are no known water shortages for municipal purposes in the study area. In some of the small communities, problems have developed in financing adequate well construction, storage facilities, and water distribution systems.

Additional M&I water will be supplies to selected cities in Pima, Pinal, and Cochise Counties through the construction of the authorized Central Arizona Project (CAP). Water from the Colorado River system will be made available through the Salt-Gila Aqueduct to areas in Pinal and Pima Counties, while areas in Cochise County will benefit from additional supplies developed from the San Pedro River. In addition, two planned dams, Buttes and Charleston, located on the Gila And San Pedro Rivers, respectively, will have a total combined conservation storage of about 203,000 acre-feet. Although water supplies are generally adequate for M&I purposes, there are local situations where wells and storage and distribution systems are inadeuqate to meet the peak demands for domestic use and fire protection. The existing water supply and distribution needs in the rural communities of Cochise, Pima, and Pinal Counties are given in Table 5.6.

In Santa Cruz County, valley fill is not as thick as in other counties; and where concentrated development has occurred, the aquifers have been pumped dry on occasion. Nogales has a recurring water shortage problem. The present source of supply is a well field developed in a limited aquifer in the streambed of the Santa Cruz River, both upstream and downstream from the State Highway 82 bridge. The water bearing alluvium is small in a real extent and is underlain by a non-water bearing conglomerate. Although the ground water is recharged by streamflow in the river, the water level drops dangerously low during periods of extensive pumping or drought.

Recent studies have indicated three possible sources of water for future development in Nogales. These include (1) surface flows of the Santa Cruz River, (2) surface flows of Sonoita Creek, and (3) ground water along the Santa Cruz River in the Calabasas area.

Municipal and industrial water demands in the Graham and Maricopa Counties' portion of the study area are limited and, thus, were not considered or discussed in this section of the report.

Large quanitites of water are required for mineral production and processing in the study area. Electrical power generation also requires minor amounts of water. The copper industry, the largest use of water in the mineral resource section of the economy, makes extensive use of recirculated and transferred water. Of the total water required for a

plant's operation, 74 percent is either recirculated or transferred water. Thus, only 26 percent of the total water required to process a ton of ore is new water, i.e., water used for the first time in the operation. 1/

1/ Percentage figures based on weighted average of 14 plants' operations as shown in Figure 7, Bureau of Mines Information Circular 8162, "Water Requirements and Uses in Arizona Mineral Industry, 1963" (48).

TABLE 5.6

EXISTING WATER SUPPLY AND DISTRIBUTION
NEEDS IN RURAL COMMUNITIES
OF
COCHISE, PIMA, AND PINAL COUNTIES

Community Or Developed Area	Existing * Needs				
	1	2	3	4	5
Cochise County					
Tombstone	X	X			
Willcox	X				
Benson	X				
Huachuca City	X	X			
Sierra Vista				X	
Naco					
Pima County					
Green Valley					
Marana			X	X	
Tucson	X			X	
Rillito			X		
Pinal County **					
Casa Grande					X
Arizona City					X
Cactus Forest					
Dudleyville				X	
Kelvin & Riverside				X	
Marana Air Park					
Oracle	X				
Maricopa	X				
Picacho					
San Manuel	X				
Stanfield	X				
Val Vista					
Lake in the Desert					
Coolidge					X
Eloy	X				
Florence		X			X
Kearny					
Mammoth	X				X
Aravaipa		X			
La Palma	X				
Mountain View	X				
Coronado				X	

(See next page for footnotes)

Footnotes to Table 5.6

Needs Classification:

1. Replacement and/or modification (expansion) within the distribution system.
2. Water storage or additional storage facilities.
3. Combining of water systems for more economical delivery of services or consideration of municipal ownership and operation of water supply system.
4. Water supply augmentation.
5. Modification and expansion of equipment utilized in supplying water to distribution networks (well motors, booster pumps, etc.).

* Existing needs based on data developed by Planning Division, Development of Economic Planning and Development, State of Arizona, and published in "Environmental Services Needs Study" for the respective counties.

** Data for Pinal County were interpreted by Soil Conservation Service personnel from "Comprehensive Plan for Water and Sewer Development in Pinal County, Arizona" as developed and submitted to the Pinal County Planning Commission by the Ken R. White Company, December, 1969.

Other

Surface water supplies needed for recreational purposes are definitely in short supply in the study area. The demand for boating, water skiing, and other water-based recreational activities amounted to over 29,500 acres or 731,000 recreational activity occasions for the base year, 1970. Needs for fish and wildlife are not included. The present surface water supply for recreation, including fish and wildlife, is about 600 surface acres. Partial fulfillment of this recreational need will be accomplished through the construction of the Buttes Dam, a component of the Central Arizona Project.

MINING AREAS

Environmental changes and the exhaustion of valuable natural resources are the problems identified in mining areas. The most obvious impacts of mining are scarring of the landscape by open-pit mining, pollution of the air by smelting, and the accumulation of waste and tailings. Refer to the Vegetation, Croplands, Mining, and Urban Lands Map for location of mining lands.

If not reclaimed, surface-mined areas, waste dumps, and tailings become wastelands. Runoff erodes these areas and carries sediment and chemical pollutants to surface and underground waters. Also, these unprotected sites are sources of blowing dust, thereby degrading the quality of the air.

Lands distrubed by surface mining can be reclaimed from hazardous eyesores to useful lands. Such uses include range, pasture, woodland, wildlife habitat, recreation areas, crop production, and building sites. With proper treatment, partial ans sometimes complete restoration of landscape beauty and usefulness can be achieved.

While needed, Arizona has no statute governing the reclamation of surface-mined private lands. Several mining companies, however, are making considerable efforts in vegetating waste dumps. There are regulations concerning reclamation of state and federal leased lands.

WATER QUALITY IMPAIRMENT

The major water quality problems involve dissolved solids in ground water and sediment in surface water. Surface and ground water naturally occurring dissolved minerals. Natural pollution results where minerals are dissolved as water flows over soil and rock surfaces. Generally, the concentration of dissolved solids is intensified as water drains downward and moves within aquifers dissolving soluble minerals. Natural pollution also occurs in some areas where water from a poor quality aquifer leaks along faults and fractures into better quality aquifers.

Surface and ground waters are so closely related in the study area that separation of the two is difficult when discussing the effects of

pollutants on water quality. The ground water reservoirs are replenished by recharge from surface waters, and some streams are fed by discharges from ground water. Because of the arid nature of the area, surface water is quite limited; and ground water is the major source of supply. Since surface and ground water are subject to both natural and man-caused pollution and since the potential for pollution is intensified with population growth, man has little choice but to take strong measures to protect this invaluable resource.

At present, known pollution of water supplies by municipal and industrial wastes is minimal. In the past, heavy metals were detected in ground water in the Tucson vicinity near the location where injection wells were used for disposal of metal-plating waste (49). However, this method of disposal has ceased.

Nearly all of the areas within incorporated cities have sewage collection and disposal systems. Plans are formulated, or will be formulated within a few years, to extend sewage collection systems into nearly all of the septic tank areas of each city.

Municipal effluents are usually discharged into normally dry streams and seep underground before reaching intermittent or perennial streams. Such seepage, as well as seepage from waste stabilization ponds, may transport pollutants to the water table.

The Tucson Wastewater Reclamation Project includes an effort to reclaim municipal effluent through irrigation with sewage. While the overall results are extremely promising, increasing nitrates have been detected in the ground water (50).

Many residences in rural areas, and some in and around incorporated cities, are not served by sewage collection and treatment facilities. Presently, in the rural areas, the predominant method of sewage treatment is the septic tank system. Cesspool treatment is possibly the second most frequently used treatment method. Some of the rural areas using the septic tank system are located on soils which are not suited for this type of disposal. In addition, some of these areas have shallow, individual domestic wells interspersed between the septic tank disposal systems. The use of septic tanks is particularly hazardous on the flood plains of the San Pedro and the Upper Santa Cruz Rivers where the water table is above or very near the streambed. If the ground water gradient is toward the river, there is high risk that, once the ground water becomes polluted, surface water will become contaminated.

The people of many of the smaller and economically deprived rural communities cannot afford to install centralized sewage collection and disposal systems. Even with allowable grants and long-term loans available, it is doubtful that minimum monthly payments for these facilities could be sustained by the marginal incomes.

Retirement and resort communities are growing rapidly in the study area. Adequate sewage treatment and disposal systems are not always provided. Most of this type of growth is occurring in Santa Cruz, Cochise, and eastern Pima Counties and is most notable along the Santa Cruz River between Nogales and Tucson.

Drainage from mining operations contains toxic elements which should not be allowed to reach streams or ground water. Acid mine drainage is not the problem in this area that it is in some because of the neutralizing effect of alkaline soils. Metallic copper in mine drainage water is a potential water pollutant, but drainage waters are often processed to salvage copper (51). The processed waters are usually disposed of by evaporation in ponds rather than being released into water courses. In some areas, the ponds are sealed or lined, thus minimizing the pollution hazard.

Irrigation has an adverse effect on water quality because of its tendency to concentrate salts. Consumptive use of water by crops and evaporation remove water but leave mineral accumulations on or near the land surface. To prevent inhibited growth of plants, excess water is applied to leach the accumulated minerals beneath the root zone. Some of the surplus water often reaches ground water reservoirs. When ground water occurs at shallow depths, the concentration of dissolved solids is increased. Part of the fertilizers applied to the soil, primarily nitrates, are also carried downward by the surplus water. However, there is little evidence that ground water quality is effected by excess application of irrigation water where the water table depth is several hundred feet.

Ground water beneath the Willcox Playa contains considerably higher concentrations of dissolved solids than that of the surrounding area. Cones of depression have formed by pumpage in the Kansas Settlement area, southeast of the playa, and Stewart area, north of the playa. These cones of depression could result in contamination of good quality water by causing ground water to flow from beneath the playa to many wells.

Vegetation which depends on a water table for survival has an marked effect in some areas on the content of dissolved solids in ground water. As phreatophytes use large volumes of water, the salts are left behind, thus concentrating dissolved solids in ground water. Only that portion which grows along live streams has this effect.

Animal wastes are not known to cause any major water pollution problems in the study area. However, the trend toward confined feeding of livestock and poultry does present potential water quality hazards. Surface water is particularly susceptible to pollution by animal wastes washed from feedlots. Also, the ground water pollution hazards is significant in areas of shallow water tables or highly porous soils. The major problem is nitrate contamination. Careful management and selection of feedlot and poultry ranch locations becomes especially important with consideration of the expected continuation of increasing dependence on concentrated feeding of livestock and poultry.

Solid waste disposal, a significant source of pollution in other areas, is not causing notable ground water pollution problems in the study area. Generally, deep water tables and low precipitation account for a lack of transfer of pollutants from sanitary landfills to ground water bodies. Special care must be observed, however, in selection of landfills. Areas of shallow ground water occurrence, such as the flood plains of the Upper Santa Cruz and the San Pedro Rivers, should not be used for landfills.

Recreation activities which are concentrated near surface water present potentially significant pollution hazards. Waste disposal is generally by septic tank, pit privies, and vault toilets. Inadequate facilities are partially responsible for indiscriminate dumping of waste from recreation vehicles. The growing popularity of such activities as camping, hunting, picnicking, hiking, horseback riding, motorcycling, boating, and fishing will require increasing efforts to prevent considerable pollution of both surface and ground water.

Surface water quality problems associated with suspended sediment are discussed in the Water Quality, Erosion, Sediment, Mining Areas, and Municipal and Industrial Waters sections. Sound planning and development of communities, proper management and treatment of rangeland, forest land, and cropland, reclamation of mined areas, and trapping and storage of sediment require increasing attention to prevent sediment from seriously degrading water quality. The most urgent need is in the San Pedro Valley, where a high rate of sediment production is responsible for a persistent water quality problem in the waters diverted for the San Carlos Project.

MANAGEMENT AND CONSERVATION OF LAND AND WATER

Agricultural Irrigated Land And Irrigation Water

Long growing seasons and high crop yields have encouraged the development of irrigated croplands in the Santa Cruz-San Pedro River Basins. The greatest restraint to such development is the availability of suitable irrigation water in sufficient quantity.

Due to the lack of water and other factors, nearly 30 percent of the land developed for irrigation in the study area remains idle each year. A large percentage of this idle acreage is located in Pinal County.

A summary of acreages within the irrigated areas is shown in Table 5.7 Further acreage breakdown is found in Chapter 4, Present Land-Use Cultivation. The location of irrigated lands is shown on the Critical Ground Water Areas and Irrigated Lands Map.

Although crops may be grown with relatively high yields, there are problems in the development and maintenance of irrigated croplands. Some problems are localized, others are general. Such problems include inadequate water supply and irrigation systems; insufficient water

TABLE 5.7

SUMMARY OF IRRIGATED ACRES IN THE

SANTA CRUZ-SAN PEDRO RIVER BASINS (1970) 1/
(Acres x 1000)

County	Cropland	Idle Land	Total
Cochise	110.6	15.9	126.5
Graham	22.0	0.3	22.3
Maricopa	-	-	-
Pima	62.1	1.6	63.7
Pinal	198.4	131.7	330.1
Santa Cruz	3.8	2.7	6.5
Type IV Area	396.9	152.2	549.1

1/ Does not include an estimated 40,900 acres of roads, highways, ditches, farmsteads, etc., within the irrigated area.

management on the land; poor soil conditions; soil erosion; salt concentrations in the soil and in irrigation water; and flooding from intense storms.

Water Supply and Irrigation Systems

Water for irrigation purposes is supplied from both surface and ground water resources. It is estimated, however, that nearly 90 percent of water supply comes from ground water pumpage. Although the ground water resources in the area are vast, they are a limited resource. In many areas, past overdraft of the ground water reservoirs has caused progressive declines in the ground water table with a resulting increase in pumpage costs. In some areas, the cost of pumping water for irrigation exceeds the beneficial economic return. The continual overdraft of the ground water system will result in even greater declines. One apparent result of this overdraft has been the occurrence of earth fissures, especially in areas such as the Lower Santa Cruz and Willcox Basins where water level declines have been most pronounced (see the Water Level Change Map, back of report). Various studies support the belief that water levels declines are accompanied by consolidation of fine textured beds which have been dewatered. The consolidation evidently causes tensile stresses to be built up around the peripheries of heavily pumped areas, and this leads to the ultimate rupture of the valley fill. These earth fissures have disrupted natural drainage and irrigation water application, damaged irrigation wells and canals, caused misalignment of highways, and endangered structures such as houses, (Photos 44 and 45). Although the monetary damages to date are low, future impacts on environmental and economic resources are unknown.

With the surface water resources in the area being very limited, these water shortage problems must be considered as important water needs. The construction of Buttes and Charleston Dams, as authorized by the Central Arizona Project (CAP), will provide the opportunity for the storage of water for irrigation and municipal and industrial purposes. These structures will be located on the Gila and San Pedro Rivers, respectively. Buttes Reservoir will be used to capture and store water released from the San Carlos Reservoir as well as runoff from the San Pedro River and other tributaries below Coolidge Dam. Water for Charleston Reservoir will come from the flow of the Upper San Pedro River. However, since the allocation of CAP water is now known, further discussion of these additional sources of supply will not be made in this resource inventory.

A limited source of surface water for irrigation will be supplied by the Tat Momolikot Dam recently constructed on the Papago Indian Reservation by the Corps of Engineers on Santa Rosa Wash near Vaiva Vo. This structure forms Lake St. Clair, which has 15,000 acre-feet of conservation capacity below the spillway crest. Approximately 3,620 acre-feet of this capacity has been allocated for direct irrigation of project lands on the Reservation.

One of the largest potentials for improved water supplies in the area lies in water conservation and salvage. An increase in irrigation

Photograph 44
Earth Fissure threatening homes. *(SCS Photograph)*

Photograph 45
Earth fissure in irrigated cropland. *(SCS Photograph)*

efficiency of about 20 percent would conserve an estimated 362,000 acre-feet annually. This water could be reserved for future use or used to irrigate an additional 80,000 to 90,000 acres annually.

Irrigation systems operating at less than 60 percent efficiency of water use result in reduction of crop yields and inefficient use of fertilizer by deep percolation in one part of the field and inadequate water supply for crop growth in another part of the field. Irrigating excessively sloping fields results in large amounts of tailwater which may be either lost to non-beneficial consumptive use or captured and used to irrigate lower fields. The latter is inefficient due to lack of control of the amount, timing, and scheduling of irrigations. Tailwater recovery systems help to improve the efficiency of this type of irrigation. Other factors on the farm that result in low irrigation efficiencies include:

(1) Irrigation runs too long.
(2) Insufficient water measuring devices in the system.
(3) Borders not properly spaced to meet the needs of the soil, slope, crop, and water supply.
(4) Insufficient water control structure.
(5) Insufficient ditch lining or piping to reduce seepage, provide control, and reduce excessive maintenance.
(6) Overall system design considerably below the potential with present technology.

Improved efficiencies both on and off the farm can be accomplished through the installation of improved irrigation systems and by the application of new and improved management techniques.

Off-farm supply and conveyance systems improvement opportunities are listed in Table 5.8. Although U.S. Department of Agriculture programs are available for assistance in installation of off-farm treatment practices, very little has been accomplished in this area with the on-going program. In the past, however, it has only been in the San Carlos and St. David Irrigation Districts and in the Pomerene Canal and Marana areas that these practices were needed. The remaining portion of the area is supplied irrigation water through on-farm wells, and off-farm conveyance systems have not been needed.

With the authorization of the Central Arizona Project, there is a requirement that before any irrigation district can contract for water its coveyance systems must be provided and maintained with linings adequate to prevent excessive conveyance losses. There is also the requirement that irrigation pumpage within the district must be reduced by an amount equal to the amount of water supplied by the project.

In addition to the need for lining the canal and distribution systems or putting in pipe, existing off-farm systems need to be enlarged and realigned. Additional off-farm control structures are also needed. There is a need for a premanently installed diversion structure on the San Pedro River to divert water into the St. David Irrigation Canal.

TABLE 5.8

IRRIGATION WATER SYSTEM AND MANAGEMENT IMPROVEMENT POTENTIAL

SANTA CRUZ-SAN PEDRO RIVER BASINS

Treatment Opportunities	Unit	Unit Cost ($1000)	Cochise County Quantity	Cochise County Installation Cost ($1000)	Graham County Quantity	Graham County Installation Cost ($1000)	Pima County Quantity	Pima County Installation Cost ($1000)	Pinal County Quantity	Pinal County Installation Cost ($1000)	Santa Cruz County Quantity	Santa Cruz County Installation Cost ($1000)	Total Type IV Area Quantity	Total Type IV Area Installation Cost ($1000)
OFF-FARM SUPPLY & CONVEYANCE IMPROVEMENT														
SUPPLY IMPROVEMENT														
Reservoirs	No.								[illegible]	510			1	510 1/
Storage	1000 AF								[illegible]				[illegible]	
Diversion	No.	70	1	70									1	70
Supply Management	1000 AF	1/	43		[illegible]		56		248		7		362	
CONVEYANCE SYSTEM IMPROVEMENT														
Consolidation	1000 FT	1/							200				200	
Realignment	1000 FT	1/	5						200				205	
Lining & Piping	1000 FT	11	90	987			5	55	2722	30000			2817	31042
Enlargement & Lining	1000 FT	7	120	840					-				120	840
Control Structure	No.	2/	83	8					2600	2600			2683	2608
Subtotal				1905				55		33110				35070
ON-FARM APPLICATION IMPROVEMENT														
APPLICATION IMPROVE.														
Ditch Piping & Lining	1000 FT	2	2419	4838	241	482	856	1712	6550	13100	81	162	10147	20294
Land Leveling	1000 AC	100	55	5530	9	900	34	3410	165	16520	[illegible]	290	267	26650
Control Structures	No.	50	-	-	4700	235	5500	275	3550	178	520	26	14270	714
Method Change to:														
Sprinkler	1000 AC	200	20	4000	6	1200	[illegible]	4000	-		1	100	47	9300
Drip	1000 AC	150	-		-		5	750	-		-		5	750
Basin	1000 AC	3/	-				25		165		[illegible]		192	
Tail Water Recovery	1000 AC	10	13	128	2	16	1	12	-		-		16	156
IMPROVED MANAGEMENT														
Timing & Scheduling	1000 AC		46		[illegible]		16		135		1		204	
Proper Appli. Rates	1000 AC		92		12		31		169		[illegible]		306	
New & Better Technology	1000 AC		7		20		16				1		44	
Automation	1000 AC	275	15	4180	-		-		-		-		15	4180
Subtotal				18676		2533		10159		29798		578		62044
POTENTIAL EFFICIENCY														
Less than 60%	1000 AC		-		-		-		-		-		-	
60 to 80 %	1000 AC		[illegible]		18		12		40		[illegible]		168	
More than 80%	1000 AC		16		[illegible]		50		159		1		229	
ON-FARM EROSION CONTROL & SOIL MGT.														
Conservation Cropping Systems	1000 AC	1	110	110	22	22	62	62	198	198	4	4	396	396
Crop Residue Mgt.	1000 AC	1	110	110	22	22	62	62	198	198	4	4	396	396
Minimum Tillage	1000 AC	4/	44	-	9	-	25	-	80	-	2	-	160	-
Mulching	1000 AC	15	4	60	1	15	3	38	8	120		[illegible]	16	236
Proper Pasture Mgt.	1000 AC	1	12	12	2	[illegible]	[illegible]	6	20	60			39	79
Windbreaks	1000 AC	1	1916	96	383	19	1080	54	3450	173	66	3	6895	345
Critical Area Treatment	1000 AC	80	39	3088	50	3984	14	1144	25	1992	-	-	128	10208
Toxic Salt Reduct.	1000 AC	30	5	150	[illegible]	60	3	90	35	1050	-	-	45	1350
Subtotal			-	[illegible]	-	4124	-	1456	-	3791	-	[illegible]	-	13010
TOTAL				24206		6957		11670		66699		592		110124 5/

1/ Costs included in other measures.
2/ Unit cost equals $100 per structure in Cochise County and $1000 per structure in Pinal County.
3/ Basin irrigation method cost is included under land leveling.
4/ Minimum tillage reduces cost by eliminating [illegible] tillage operations.
5/ Totals may not balance due to rounding.

Again, however, it should be noted that the treatment opportunities as tabulated in Table 5.8 reflect only the needs for the present off-farm irrigation systems and do not include the necessary lengths of piping and canal linings, control structures, realignments, consolidations, etc., required by future projects.

In contrast to the lack of installation of off-farm treatment practices, many on-farm irrigation systems and management practices have been applied. The total treatment applied to date (Table 5.9) has been installed at a total estimated initial cost of $67,456,800. About 65,500 acres or 17 percent of the total irrigated land in the study area is considered to be adequately treated. Present irrigation efficiencies range from less than 50 percent to greater than 70 percent. Approximately half of the irrigated lands have efficiencies somewhere between the 50 and 70 percent range. With adequate land treatment and proper irrigation water management, overall efficiencies of 70 to over 80 percent could be attained.

Table 5.8 shows the on-farm treatment opportunities in the area. These treatment opportunities are based on the 1970 crop production acres and include piping and ditch lining, land leveling, control structures, changed irrigation method, tailwater recovery systems, and improved management techniques. It was assumed that although an additional 152,200 acres have been developed for irrigation in the area, it would not be economically feasible to treat the total area due to the lack of an adequate water supply. Even with the prospect of imported water from the Central Arizona Project, the total developed acreage probably will not be irrigated because of the restriction on ground water pumpage in the CAP service area.

From Table 5.8, it can be seen that the land leveling on Pima, Pinal, and Santa Cruz Counties is basically a method change from a "slope or graded border" system to a "basin" type of land leveling. This is a major factor which can result in higher irrigation efficiencies and better crop yields.

Management or handling the irrigation water is the other major factor influencing efficiency of water use. In contrast to physical systems installed on the land, management factors include:

(1) Use of proper application rates - the capability of knowing how much water the crops need at the time the water is applied.

(2) Timing and scheduling - the capability of knowing when the crops need water and schedule such delivery.

(3) Followup to determine if the water applied was the correct amount.

Irrigation efficiencies on over 306,000 acres or about 77 percent of the total acreage used for crop production in 1970 could be increased by improved management techniques. The "on-going" educational program for improved management needs to be greatly accelerated.

TABLE 5.9

IRRIGATION SYSTEM AND MANAGEMENT PRACTICES APPLIED AS OF 1970

SANTA CRUZ-SAN PEDRO RIVER BASINS

TOTAL IRRIGATED CROPLAND ACRES			126,500 Cochise County		22,300 Graham County		63,700 Pima County		330,100 Pinal County		6,500 Santa Cruz County		549,100 Total Type IV Area	
PRACTICES	Unit	Unit Cost ($1000)	Total to Date	Installation Cost ($1000)	Total to Date	Installation Cost ($1000)	Total to Date	Installation Cost ($1000)	Total to Date	Installation Cost ($1000)	Total to Date	Installation Cost ($1000)	Total to Date	Installation Cost ($1000)
OFF-FARM SUPPLY AND CONVEYANCE IMPROVEMENT														
SUPPLY IMPROVEMENT														
Storage	1000 AF								967	3/			967	3/
CONVEYANCE														
Diversion [illegible]	[illegible]	70.0	1	70									[illegible]	70
Canals or Laterals	1000 FT	1/	208	1039			[illegible]	25	2722	2722[illegible]			2935	28282
Canal Lining	1000 FT	2/	2	16			333	3330	3	26			338	3372
Pipeline	1000 FT	10.0	1	10									1	10
Control Structure	No							–	800	800			800	800
Subtotal				1135				3355		28044				32534
ON-FARM IRRIGATION SYSTEM AND MANAGEMENT IMPROVEMENT														
SYSTEM IMPROVEMENT														
Sprinkler	1000 AC	200.0	11	2120	2	400	[illegible]	600	0	80	1	190	17	3390
Surface	1000 AC	4/	116		18		40		33		6		214	
Pipelines	1000 FT	3.0	1062	3187	319	657	281	843	415	1245	98	294	2175	6226
Ditch Lining	1000 FT	1.75	2893	5063	25	44	2710	4743	9960	17430	197	345	15785	27625
Field Ditch	1000 FT	0.2	2419	484	2	0	324	65	3320	664	15	3	6080	1216
Land Leveling	1000 AC	100.0	57	5740	5	500	41	4100	148	14800	[illegible]	400	255	25540
Land Smoothing	1000 AC	20.0	33	652									33	652
Overnight Reservoirs	No	1.2	180	216	10	12	36	43	1	1	13	16	240	288
Control Structures	No	0.05	3816	191	100	5	2478	124	2490	125	779	39	9663	484
Tailwater Recovery	No	2.0	184	368	21	42	17	34	83	166			302	610
Drains - Tile	1000 FT	3.0	1	4									1	4
- Open	1000 FT	2.0	38	75									38	75
MANAGEMENT IMPROVEMENT														
Irrigation Water Management	1000 AC	1.0	23	23	2	2	[illegible]	2	33	33	1	1	62	61
TOTAL ADEQUATELY TREATED	1000 AC		10		1		19		33		2		66	
Subtotal				18123		1662		10554		34544		1268		66171
PRESENT EFFICIENCY														
Less than 50%	1000 AC		20		3		36		149		[illegible]		212	
50 to 70%	1000 AC		95		17		20		149		2		283	
More than 70%	1000 AC		12		3		8		33		1		57	
ON-FARM EROSION CONTROL AND SOIL MANAGEMENT IMPROVEMENT														
CONSERVATION CROPPING SYSTEM	1000 AC	1	72	72	3	3	36	36	150	150	[illegible]	3	264	264
CROP RESIDUE USE	1000 AC	1	56	56	3	3	33	33	180	180	3	3	275	275
MINIMUM TILLAGE	1000 AC	5/	25		2		28		90		1		146	
MULCHING	1000 AC	15							9	132	0	2	9	134
PROPER PASTURE MGMT.	1000 AC	1	6	6	1	1	1	[illegible]			[illegible]	[illegible]	9	[illegible]
WINDBREAKS	1000 L.FT	.05	2	0			[illegible]	0	8	0			18	0
WILDLIFE UPLAND MGMT.	1000 AC	5					1	[illegible]					1	[illegible]
TOXIC SALT REDUCTION	1000 AC	30	1	30	0	3			19	570			20	603
Subtotal				164		10		73		1032		9		1200
TOTAL				19422		1672		13982		[illegible]3620		1297		99993

1/ Unit cost equals $5 per foot in Cochise and Pima Counties and $10 per foot in Pinal County.
2/ Unit cost equals $8 per foot in Cochise and $10 per foot in Pima and Pinal Counties.
3/ Cost unknown (San Carlos and Pichaco Reservoirs).
4/ Cost included in other items.
5/ Minimum tillage reduces cost by eliminating [illegible] tillage operations.

Soil Condition and Erosion

Poor soil conditions are inherent in most desert and semi-desert climates. Major factors causing this condition include:

(1) Inherent low organic matter content in the soil.
(2) Soil structure that impedes roots and water.
(3) Some soils tend to accumulate enough salt to restrict growth of some plants.
(4) Compaction of soil from use of machinery.

All of these factors tend to restrict water, air, and plant root movement through the soil. Soil conditions are poor enough in some areas to cause difficulty in plowing, discing, or otherwise preparing the seedbed. Practices to replace organic matter, improve soil structure, and guard against compaction are generally needed.

Soil erosion on cropland is generally slight except in small, localized areas along the San Pedro River and in Graham County where moderate to severe erosion occurs.

Most of the cropland erosion is caused by short duration, intensive rainstorms, usually during July and August. These storms produce enough runoff on fields with slopes in excess of 0.3 percent to cause severe soil loss. For the Casa Grande area, the average annual soil loss caused by rainfall erosion on an unprotected acre of silty soil, with a one percent slope and a 1,000 foot slope length, would be about four tons. 1/ The soil loss in the Douglas area, with similar soil and slope conditions, would be about seven tons. The reason for the difference is the greater rainfall intensity in the Douglas area. Three to five tons per acre per year is considered a tolerable soil loss for soils more than 40 inces deep.

The ability of the soil to resist erosion is reduced in those areas where salts have concentrated in the soil, excessive tillage is used, organic matter content has not been maintained, and/or soil compaction has occurred.

Soil erosion by wind is active during the time frontal storm systems move across the area. Areas with sandy soils and fallow or idle croplands are most susceptable. Wind erosion occurring on such lands adjacent to heavily traveled freeways results in a serious safety hazard. This dust also pollutes the air.

Salt Concentration

Note the variation in sodium and salinity of irrigation waters as shown on the Well Water Irrigation Classification Map, back of report High and very high sodium and salinity concentrations in irrigation waters tend to reduce crop yields; and, in some cases, croplands are abandoned.

1/ Based on use of the Universal Soil Loss Equation.

The On-Farm Erosion Control and Soil Management portion of Table 5.9 is a summary of practices applied to the land and costs as of the year 1970. Costs indicate the magnitude of the land treatment program. However, these costs vary from area to area and by level of technology used. The costs represent initial or one-time installation costs and do not include replacement, updating, or maintenance. Replacement and updating of the practices is necessary when they deteriorate or no longer serve the purpose intended. Each time a practice is replaced, additional costs similar to initial costs are required. The time period or life span varies with individual practices and ranges from one to thirty years.

Improvement potential is summarized for the Erosion Control and Soil Management portion of Table 5.8. Costs on this table represent magnitude and one-time costs as described for Table 5.9.

Plant Cover, Rangeland, and Livestock Water

Reduced productivity of plant communities is the foremost range problem of the Santa Cruz-San Pedro River Basins. Of the many influences causing reduced productivity, displacement of grassland communities by unpalatable trees and shrubs is most prevalent. Mountainous areas covered with dense woodland-chaparral stands are highly susceptible to wildfire and have limited usefulness for livestock and game animals. Wildfires in woodland-chaparral are extremely costly to control. Soil erosion under dense woodland-chaparral stands becomes apparent only after denudation by wildfire. At the highest elevations, open conifer forests and open meadows have been invaded by understory trees and shrubs and have become choked with forest debris. Overstory tree and shrub densities in woodland-chaparral areas have also increased with a consequent loss of understory grasses and forbs. Displacement of forage grasses and forbs by mesquite, burroweed, snakeweed, and other woody species has reduced the productivity of desert grasslands. Grassland communities of the Chihuahuan Desert area in which woody species were once controlled by re-occurring wildfires, have been taken over by creosote bush, whitethorn, Mortonia, tarbush, mariola, graythorn, saltbush, catclaw, mesquite, and other woody species. With its sparse cover of shrubs, the Chihuahuan Desert is subject to erosion. In the Sonoran Desert, low growing shrubs and half shrubs have been displaced by larger woody species such as mesquite, catclaw, ironwood, paloverde, yuccas, and cholla cacti.

Grassland communities have been restored by conversion treatment in local areas of woodland-chaparral, Chihuahuan Desert, and shrub-infested desert grasslands. One of the major needs of the area is to step up the rate of restoration in order to exceed the rate of shrub invasion.

Reduce grazing use has resulted from speculative real estate sales of some of the best grasslands located considerable distances from established towns and cities (Photo 46). Many such sales are occurring in areas

Photograph 46
Grassland broken up by crossroads in speculative land development in the Douglas Basin. *(Forest Service Photograph)*

without firm supplies of water and without adequate studies to determine the future dependability of water supplies. The impact goes beyond subdivision boundaries as sediment derived from eroded road systems within the subdivided area is deposited in downstream areas. Gullies, initiated by improper road construction often advance headward into surrounding areas. Although recent legislation may discourage future real estate speculation, it does not solve the problems of restoring lands that are already subdivided and have road systems established. Restoration of subdivided areas which are in excess of projected needs becomes a most difficult problem where ownership involves many people living in other states.

Rangelands have been reduced in size by roads, energy transmission lines, and communication lines. In addition to the loss of areas fenced agains livestock, grazing use is complicated by the isolation of small parcels of range. Unfenced service roads are a growing source of range disturbance along overhead telephone and electric power lines and along underground gas and petroleum pipelines. The problem involves keeping transportation, communication, electric, gas, and petroleum transmission lines confined to present routes so that the remaining rangelands can be protected from further disturbance plus the need to obliterate roads and reduce access.

On 132,000 acres of wilderness, national monuments, and other special areas, grazing by livestock is either prohibited or permitted without benefit of range management practices such as brush management, reseeding,

construction of watering facilities, or distribution trails and supply roads.

Extreme fluctuations in the production of forage and browse are largely the result of natural variation in annual and seasonal rainfall. Such variations are characteristic of the southwestern climate. On desert and desert grassland ranges, two forage crops can be produced during infrequent years when both winter and summer precipitation and temperatures are favorable; but little forage can be produced in those years when precipitation and temperatures are unfavorable during consecutive winter and summer seasons.

To cope with these extreme variations in forage supplies, the most successful ranches maintain a large proportion of steers in their herds. During severe droughts, steer calves can be sold to avoid great death losses. In years of favorable moisture and above average forage production, steer calves can be held over or additional animals can be obtained for the season.

Although a large number of charcos, dams, and diversion structures have been built, and large areas have been converted from brush to grass on the Papago Indian Reservation, failure to use flexible livestock management has caused deterioration of desert ranges and resulted in losses of livestock. Because of this herd inflexibility, about 1,000 head of livestock were lost on the Papago Indian Reservation during extended droughts in 1969. 1/ Following the severe drought of 1969, the reservation provided 104,200 animal unit months of grazing. With an estimated 8,600 head of cattle and 2,070 head of horses on the reservation, the Sonoran Desert ranges have been overstocked. Similar losses occurred again in 1974.

While Herefords and mixed Mexican cattle have prevailed throughout the study area, there are many new breeds being tested and developed for better adaptation to arid conditions. Brahma cattle have been involved in several crosses for building up resistance to diseases and better tolerance to high summer temperatures. Brangus (Angus and Brahma) is a cross which was developed near Nogales and is in growing demand. Light colored Charlois cattle are being used as purebreds and in crosses with other popular breeds. Further testing and widespread use of the more productive, disease-free, and drought-adapted crossbred cattle need to be emphasized in the study area.

Remote range areas that presently receive little grazing use still need to be made available to livestock by construction of watering facilities and location of new salt grounds.

Progress has been made in shifting toward rotation systems of grazing, but some ranches still practice year-long grazing. Prescribed burning can be used in combination with deferred-rotation systems of grazing as a management tool to increase forage production. Grass and herbaceous ground cover will have to be protected from grazing use through one

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1/ Papago Indian Reservation Reports.

growing season to provide the fuels needed to carry fire. Also, a burned-over range unit will need to be protected to favor recovery of the grass and forb plants.

Water developments for livestock are summarized in Table 5.10. These include earthen dams and charcos, wells with windmills and pumps, metal storage tanks, and springs. Twenty-four percent of all earthen dams and charcos are located on Coronado National Forest lands which make up only 12.5 percent of the study area. The greater numbers of stock dams on national forest lands are related to the longer duration of storms and larger amounts of precipitation associated with the high mountain masses. By way of contrast, only seven percent of the wells with windmills and pumps occur within the mountainous national forest lands. Ninety-three percent of the wells with windmills and pumps are located at lower elevations and along the tributaries draining into the Santa Cruz and San Pedro rivers and the Willcox Playa. The greater number of wells and windmills at lower elevations is related to the greater thickness of aquifers. Sixty percent of the springs occur within the Coronado National Forest and are related to the high rainfall patterns of the higher mountain ranges.

Springs and wells provide the most dependable sources of water for livestock. In some local areas, wells have been located on hilltops in contrast to the more common location along drainage courses. Widespread distribution of wells in such areas helps meet the objectives of getting the desired distribution of grazing animals.

Most problems involving the development of water for livestock are associated with ponds and charcos. High losses of water impounded behind earthen dams and in charcos is caused by seepage and evaporation. While both evaporation and seepage can be reduced by applications of specific chemicals, water can be more effectively saved by shifting from earthen dams and charcos to tanks made of metal, concrete, plastic, or butyl rubber.

Maintaining storage capacities of earthen tanks and charcos against displacement by sediment is another problem. Where the annual deposition of sediment is not too great, periodic removal of deposited materials is practical to maintain storage capacities of earthen tanks. Where large amounts of sediment are deposited frequently, removal operations are usually too costly to justify continued use of the facility.

Muddy water in ponds is a problem during and after flooding and is prolonged by the trampling action of livestock. Muddy water absorbs the sun's rays more than clear water and, consequently, becomes warmer and subject to more rapid evaporation.

Primarily located along drainage courses, earthen ponds do not provide the flexibility needed for getting the desired distribution of livestock and even grazing use of forage. Where livestock water is limited to earthen ponds, nearby drainage courses may be overgrazed while distant slopes and ridges may be under-utilized.

TABLE 5.10

LIVESTOCK WATER DEVELOPMENTS
SANTA CRUZ-SAN PEDRO RIVER BASINS

Sub-Basins and Management Units	Earthen Dams and Charcos	Wells with Windmills and Pumps	Metal Storage Tanks	Springs
Playa				
Coronado N.F.	78	16	4	38
Other Ownerships	429	309	23	54
Total	507	325	27	92
San Pedro				
Coronado N.F.	151	28	17	177
Other Ownerships	496	319	94	101
Total	647	347	111	278
White Water Draw				
Coronado N.F.	70	3	40	21
Other Ownerships	375	223	80	15
Total	445	226	120	36
Upper Santa Cruz				
Coronado N.F.	481	82	28	236
Other Ownerships	751	468	72	115
Total	1232	550	100	351
Lower Santa Cruz				
Coronado N.F.	-	-	-	-
Other Ownerships	399	285	50	21
Total	399	285	50	21
Summary				
Coronado N.F.	780	129	89	472
Other Ownerships	2450	1604	319	306
Total	3230	1733	408	778

Forest Land

Modern society is placing different emphasis on the use of the limited mountain forest lands. Commercial timber sales of sawlog trees in the Graham Mountains is being displaced by the type of salvage logging being practiced in the Santa Catalina Mountains. Salvage logging is the only adaptable means of harvesting trees from forests being managed mainly for recreational uses.

Management and conservation of forest lands is directed towards satisfying the diverse demands of people. Of these, demands for using cool mountain camping and picnic areas during the hot summer months can exceed the spaces available. When demands exceed supply, controls must be imposed on the numbers of people using the facilities.

As the cities and towns of the Santa Cruz-San Pedro River Basin grow in numbers of people, there is a corresponding increase in demand for recreational uses of forest lands. The frequency of forest fires increases with the increased recreational use. In the Santa Catalina Mountains, the growing problem of forest management involves fire hazard reduction, removal of over-aged decadent trees, and controls of mistletoe, insects, and diseases. There is the growing need for maintaining open forest stands to make them resistant to destruction by wildfire. Protection from wildfire requires thinning trees and reducing forest fuels from firebreaks around camps and picnic areas.

In 1971, there were 201 fires that burned 4,195 acres within the national forest boundaries. Of these, 87 fires were nine acres or less in size, 106 fires were between nine and one hundred acres, and eight fires were over 100 acres. Twenty percent of the fires were man-caused.

The number of fires occurring on State and private lands in the study area and the entire State in 1970 and 1971 are listed in Table 5.11, page 5.55. Also shown are the number of fires by county within the study area and the percentages compared to the total fires in the State.

Associated with the construction of camping and picnic sites is the problem of building access roads and parking areas. Determining how much space should be cleared of forest trees and shrubs for access roads and parking areas becomes a serious problem when there are only 130,574 acres of the conifer forest type in the study area. Parts of this acreage are in wilderness and on steep slopes that are unsuitable for locating camp and picnic sites.

Other uses of forest lands that require the clearing of trees for space include: skiing facilities such as ski courses, lodges, and access roads; radio and television transmission and relay towers and service roads; and observatories related to astronomy and space explorations.

Providing space to accomodate increasing numbers of people enlarges the problems of providing safe drinking water and disposing of sewage wastes so that streams carrying water to downstream camping and

TABLE 5.11

NUMBER OF FIRES OCCURRING ON STATE AND PRIVATE LANDS DURING 1970 AND 1971 IN SANTA CRUZ-SAN PEDRO RIVER BASINS AND IN THE TOTAL STATE 1/

County	1970		1971	
	No. of Fires In River Basin	% of State Total	No. of Fires in River Basin	% of State Total
Cochise	8	8	20	9
Maricopa	5	5	2	1
Pima	2	2	2	1
Pinal	2	2	3	1
Santa Cruz	6	6	69	32
River Basin Total	23	23	96	44
State Total	101	100	218	100

1/ Information provided by the Forestry Division of the State Land Department. No data for Graham County.

picnic areas will not be polluted. Evaluations are presently being made to determine if forest lands can help satisfy growing demands for recreation, lumber, and for production of water, livestock and game.

Urban and Industrial Land

There is a growing concern with the economic, social, physical, and environmental consequences of unplanned urban and industrial growth. But this concern has not been properly channeled into action which will forstall unwise development. Development is still occurring that has not been properly planned and is not in balance with the ability to provide and maintain required public services and facilities. Subdivision of land is occurring years before any people arrive; these subdivisions are land speculation ventures.

Soil conservation needs in urban and urbanizing areas are complex and not fully understood by developers, land-use planning groups, and local decision makers. New construction may take place with little knowledge of the hazards or capabilities of the soil and underlying geologic strata. Some homes are built on unsuitable soils and without regard to future availability of water, power, and community services. Sites that require expensive foundations for buildings and roads are sometimes selected when equally acceptable sites better suited for foundations are available. Solid waste disposal and septic tanks have adverse effects on water quality where improperly located. Flood peaks and volumes are increased because of increased runoff resulting from impermeable construction such as paving and roof construction. During and immediately after construction, large areas are stripped of vegetation leaving the soil vulnerable to wind and water erosion for long periods of time.

The population will continue to increase in future years, and it will have to be accommodated. The question of which land should be converted to urban and other special uses is of vital importance. The primary responsibility for planning and regulating the use and development of land remains with local units of government - principally cities and counties. Local governments realize that there are benefits from looking ahead such as achieving economics of scale in systems of public facilities, preventing the emergence and aggravation of environmental hazards and nuisances, and meeting basic demands for power, transportation, and other utility services. Non-agricultural land management and conservation succeeds only when local officials recognize the planning tools they have available and use them effectively.

Any land use or management change leads to a number of effects. Some of these effects will be positive and others will be negative. These cause-effect interactions must be understood in order to be sure the right decision was made. Understanding the cause-effect relationships is the area where most land-use planners and decision makers need assistance. Specifically, the following items are needed:

1. Soil, water, and related resource data and interpretations useful in selecting sites for community developments, parks, and greenbelts.

2. Use of available information in predicting the kinds of problems that can be expected and the resource maintenance needed with respect to homes, public and commercial buildings, industrial developments, parking lots, shopping centers, and underground conduits and pipelines.

3. Planning water supply, flood control, and other related water resource developments.

4. Increased information to urban people on the need for water conservation and resource planning and on sources of help.

5. Improved soil and water conservation techniques for non-agricultural land.

6. Increased recognition by land developers of soil and water needs and problems of critical erosion, sedimentation, and water disposal.

7. Plans that include quality standards for soil and water conservation and for the orderly development of rural areas for housing, industry, transportation, and related developments.

8. Assistance in preparing and carrying out laws and ordinances for land-use zoning, erosion, sediment control, and similar measures that result in an effective soil and water conservation program.

9. Resource monitoring systems that include land in transition from rural to urban and suburban uses.

10. Improved information on soil, water, plant, and related resources.

Open and Green Space

Man, in the past, has allowed short-term economic gain to govern much of the areas in which a city expanded. In most cases, the original sites were located in areas that were only subject to flooding during the less frequent events and on soils more suitable for construction. However, as the population grew, developments intensified and began encircling the city. Land was purchased in close proximity to the existing developments and by ownership boundaries rather than suitability boundaries. Once the investment was made in a particular plot of land, it was developed without regard to future monetary or environmental damages. In many cases, the less suitable land was purchased at a low price and sold at a premium price once developed. The incentive of getting the greatest return on money invested and limited knowledge of long-term effects have contributed to elimination of natural areas least suited for development and best suited for open and green space. Public concern with open space indicates that it has diminished to levels where diversity of the environment within cities no longer satisfies human needs.

The need for open space has usually been justified for physical and psychological health benefits. The diversity which it offers also affects resource base components such as air, water, soil, plants, animals, and economic development such as tourism and real estate values. For illustration purposes, let us assume that a flood plain is designated as an open and green space. Nature trails and picnic tables are installed in the area. This allows human use but limits it so that it does not interfere with the natural functions. The open space preserved helps maintain the scenic diversity of the area, thus encouraging tourism and preventing possible property value decreases. Such lands also possess unique conservation values which maintain the natural process in balance. For instance, natural stream courses allow the passage of floodflows, act as filter beds through which ground water is recharged, and provide habitat for adapted plant and animal species. From this standpoint, nature performs work for man without his investment. Such work constitutes a value, and it is to man's benefit to preserve open and green areas in order that natural processes may continue.

The quantity of open and green space needed to fulfill human needs cannot be determined on a standardized basis such as in recreation. It should be determined on the quality and uniqueness of its characteristics and the natural processes which occur in the area.

The 25,000 acres of natural areas unsuitable for development in the Tucson area need to be preserved as open and green spaces. Swift action is needed to prevent development which would be irreversible. Measures need to be taken to preserve such areas in other smaller communities.

UNREGULATED LAND DEVELOPMENT

According to the Wall Street Journal's financial experts, the public has been spending up to six billion each year for vacation and retirement land on the installment plan. A high percentage of these investors buy this land sight-unseen. When they see their "dream plot" or try to sell it, these investors find the land unsuitable for development. The complain to federal and state regulators and lawmakers. Reports show that from 1,000 to 1,500 letters from all over the nation are received at the federal level each month from disgruntled buyers.

The rural, remote life that most residents of the study area knew in past years is rapidly changing. Irrigated croplands are becoming subdivisions; and rangelands and mountainous areas are being turned into small ranch estates. Residents are concerned, as evidenced by this excerpt from the County of Cochise Development Policies and General Plan which was published recently as a supplement to area newspapers:

> "The County is changing. It remained essentially the same for centuries. Suddenly, new patterns of development have emerged. The past two decades have witnessed a spectacular jump in land subdivision activity. More than six times as many lots have been subdivided since 1950 than had been subdivided in all times before. During the forties--145 lots. During the fifties--1,300 lots. During the sixties--36,500 lots. So far, during the seventies--28,000 lots.

It used to be that subdivisions occurred only in, adjacent, or near existing communities. Now, they are likely to be remote. Of those subdivided in the past two decades, few lots are improved. Only three precent, infact, are improved. Much subdivision activity has been premature.

The future is likely to be one of further expansion. Our population in 1970 was 61,910. We project 75,000 by 1980. By 1990, we expect 100,000.

These figures are based on historical trends. History is sometimes a poor indicator of the future. The Charleston Dam will be a major impact. Tourism is yet an untapped potential. Of interest is where newcomers will settle. Of concern is what would happen if those areas already subdivided were to become occupied. Of great concern is if this hould happen quickly. We might not recognize many areas of the county. If present trends do continue, land speculation would surely obliterate most of our valleys. Prime agricultural and grazing lands would be removed from production forever.

The typical sprawl of cities into the countryside is occurring here. There must be a better way to accommodate our inevitable growth. There is. We can locate the urban development that is coming to Cochise County wisely. The preparation and adoption of a comprehensive plan is a first priority."

Not only is Cochise County experiencing this "subdivision stampede" but the other counties in the study area as well as the remainder of Arizona are feeling the effects. Remote subdivided lands affect 1.3 percent of the total state land area. Pima County is below this average with .89 percent of its land area affected; while Pinal, Cochise, and Santa Cruz Counties are above with 1.57, 2.09, and 7.33 percent, respectively, of their land areas affected.

Data exhibited in Table 5.12, shows that remote subdivisions in the four-county area had the capacity to accommodate 775,200 people in 1974. This is more than twice the capacity needed to meet the projected rural population for the year 2000. On a county basis, a capacity ranging from 3.2 times to 13.4 times the needed capacity exists in Cochise, Pinal, and Santa Cruz counties. In contrast, an under-supply of 94,700 is projected to exist in Pima County. The 1974 population capacity of remote subdivisions for this county will meet 62 percent of the projected rural population for the year 2000.

The over-supply and under-supply figures exhibited in the table are conservative estimates because they exceed OBERS population projections for the year 2020 by about 30 percent. Also, these estimates assume that all rural population, including the rural farm population, will reside in subdivisions. Economic forces have caused the overdevelopment; economic, social, and environmental forces must work together in bringing order to the situation.

TABLE 5.12

COMPARISON OF 1974 REMOTE SUBDIVISION CAPACITY

WITH 2000 RURAL POPULATION ESTIMATES, FOUR-COUNTY AREA, SANTA CRUZ-SAN PEDRO RIVER BASINS

County	1974 Population Capacity of Subdivisions	1984 Total County Population Estimate	2000 Total Projected County Population	2000 Projected Rural Population	Population Capacity Oversupply
Cochise	254,600	75,400	116,950	30,100	224,500
Pima	151,300	435,000	1,046,750	246,000	(-)94,700
Pinal	224,300	80,500	121,100	69,300	155,000
Santa Cruz	145,000	17,400	34,450	10,800	134,200
TOTAL	775,200	608,300	1,319,250	356,200	419,000

Source: Office of Economic Planning and Development, Arizona's Remote Subdivisions, An Inventory (Office of the Governor, State of Arizona) 1975, pp. 32. (52)

Local boards need the information on which to base decisions concerning approval or disapproval of subdivisions. In a majority of cases decisions have been made without adequate information. Subdivisions have been approved which do not have adequate water supplies, sewage disposal systems, or other public utilities; lots have been located in flood plains; there has been inadequate knowledge of the probable ecological effects of construction and operation of facilities including geologic and hydrologic features, flora and fauna, and air and water quality, and esthetics. In many cases, neither has planned development fitted the capability of the land on which it is to be located nor have the needed public services been assured.

Much development has taken place or is planned that does not exhibit a high standard of design and that might place undue burdens on taxpayers. Misrepresentation of property is a sales practice used by some developers, and many lots are sold by companies which go out of business before providing promised utilities.

Until the passage of recent legislation, the Arizona State Department of Health had the responsibility to certify the adequacy of water supply, both as regards availability and quality, for all land development in Arizona. The Department of Health, however, lacked the necessary resources to make the requisite studies and had adopted a cooperative program with the Arizona Water Commission to evaluate the water supplies of those proposed subdivisions in which adequacy of supply was not obvious and/or controversy had developed. With passage of legislation entitled, "Avaialble Water Supply Notice for Subdivision Lots" (Arizona Revised Statutes, Title 32, Ch. 94), the responsibility of the adequacy of water supply for subdivisions lands was transferred to the Arizona Water Commission. This legislation requires all advertisements for subdivision lots in areas where inadequate water supply has been found, to so state; and requires developers to submit water supply plans to the Arizona Water Commission for evaluation. (Effective May 2, 1973.)

Before the effective date of the above legislation, the Arizona Water Commission, in cooperation with the State Health Department, completed a study in July 1972 concerning the adequacy of the water supply for the proposed Empire Ranch Development which is located in Santa Cruz and Pima counties just northeast of the small community of Sonoita The results of this study showed that the effects of the development's water withdrawal on the basin's ground water supply would be large but within the range of that experienced elsewhere in Arizona. The development's water supply was thus judged to be adequate for the population projections used in the evaluation.

The need for such studies is evident when analysis is made of projected water needs for presently subdivided (but yet to be developed) lands. The analysis illustrated in Table 5.13, is based on a weighted average use rate of 185 gallons per capita per day (gpcd) 1/ and

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1/ Weighted average for the four-county study area.

population capacities as given in Table 5.12.

Tables 5.12 and 5.13 illustrate the need for careful planning including consideration of social, economic, and environmental factors before lands are approved for subdivision.

TABLE 5.13

PROJECTED ANNUAL WATER NEEDS, UNREGULATED SUBDIVISIONS

County	Consumptive Use Rate (gpcd)	Population Capacity of Subdivisions	Annual Water Needs (Ac-ft.)1/
Four-County Area			
Cochise	185	254,600	52,800
Pima	185	151,300	31,400
Pinal	185	224,300	46,500
Santa Cruz	185	145,000	30,000
Total		775,200	160,700

1/ One acre-foot equals approximately 325,850 gallons.

OUTDOOR RECREATION AND TOURISM

As population increases in the country in general, and in and around the study area, in particular, it is expected that tourism and the demand for recreational facilities will also increase. It is expected that the demand for these facilities will exceed the supply.

In addition, there are several factors that tend to restrict full utilization of these facilities. First, space for high mountain camping and picnic sites is limited and, as demand for their use increases, they will become more limited as roads and vehicle parking space are expanded Second, closure of National Forest areas to recreational uses during periods of high fire hazards limits full utilization of facilities.

A third problem involves the use of areas occupied by summer homes compared to the use of public camp and picnic grounds. In 1970, of 435 summer homes located on 152 acres of Coronado National Forest land were used; while 1.8 million visits were made by people to 44 public picnic and camping areas located on 479 acres. Determining whether summer homesites should be converted to public camp and picnic areas will be needed if problems arise in providing satisfaction to the greater number of people.

The limited number of recreational facilities plus the impediments to full utilization suggest that a capacity limit scheme, such as the one established for the Sabino Canyon Recreation Area, may have to be adopted.

That is, unless the supply of recreational facilities can be increased or impediments to their full utilization can be alleviated, administrators of the public land will have to develop a management system to prevent resource damage of recreational areas.

The first of the three impediments listed here is necessary in order to provide access to the areas and accomodate vehicles. The second depends upon the whims of nature and the third may involve complicated questions of ownership of private property. It appears therefore, that the answer lies in attempts to increase the supply of facilities.

One approach to increasing the supply of recreational sites is to stimulate greater use of wilderness areas. The compared per acre use of the Chiricahua National Monument with that of the Chiricahua Wilderness Area was at the ratio of 25 people to one. With increased population and demands for recreation space, however, it is reasonable to consider greater use of wilderness areas as a possible means by which the supply of recreational facilities can be increased.

In the absence of basic sanitation facilities, printed instructions for disposing of human wastes have been printed for distribution to people visiting wilderness areas (FS 66, GPO 876-267). In order to minimize both surface disturbance and pollution, Forest administrators may be faced with making a choice between either exercising strict controls over numbers of people visiting wilderness areas or providing the sanitary facilities needed to accommodate more people.

Defenders of Wildlife has acquired the ownership of private lands at both east and west entrances to Aravaipa Canyon Primitive Area. The organization exercises control over the people entering the canyon, but public access is provided at both ends of the canyon on a permit basis. The Primitive Area and adjoining side canyons are closed to the discharge of firearms to protect public safety. The Primitive Area is closed also to motorized vehicles, but access to the south rim by vehicles can be obtained through Turkey Creek.

There are two areas which have potential for designation as wilderness areas. These are located on Forest Service administered land. One is Erickson Peak (7,200 acres) in Cochise County and the other is Tumacacori (39,600 acres) in Santa Cruz County. 1/

FISH AND WILDLIFE HABITAT

Some portions of the area appear to be relatively devoid of habitat This "badlands" condition is primarily the result of geologic erosion and is a relatively natural condition.

Activities which cause problems in the way of reduction of quality and quantity of fish and wildlife habitat do occur in the study area. Those which are most readily apparent and which potentially can cause the greatest losses are those which effect large areas.

Possibly the greatest single problem at the present time is the proliferation of large, remote subdivisions and urban development. Approximately 311,600 acres within the study area are currently being developed for these purposes. Remote subdivisions, for the most part, are designed on undeveloped lands and cause damage to the natural environment including fish and wildlife habitat. Some of these developments are well over a township in size. Many times before 1971, plats were drawn up for available lands without adequate basic data on water availability. Other factors not adequately considered are soil suitability and reasonable projections of future conditions, especially population projections. Final plans were drawn, lots were staked out, and streets roughly cut. Often development has not gone beyond this point. The result is a disruption of natural drainages, destruction of vegetation, increased wind and water erosion, and a general loss of aesthetics. The loss of wildlife habitat is especially great when developments are designed through major riparian areas, along stream courses, or in other critical habitat areas.

In these areas where vegetation has been manipulated, wildlife habitat values have decreased. Removal of trees and shrubs eliminates food, cover, and nest areas. Removal of protective vegetative cover on highly erodable sites has resulted in increased sedimentation downstream, often greatly reducing and/or degrading fish habitat in stream and reservoirs.

Riparian vegetation, or that occurring more or less under streamside conditions, is probably the single most important habitat type for the largest number of wildlife species in the study area. Riparian habitat in the lower desert areas provides woody nesting, roosting, and escape

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1/ 1973, Wilderness, Potential Wilderness, Research Natural Areas and Natural Landmarks. Working Document by U.S. Forest Service for Western U.S. Water Plan.

cover where little if any similar habitat exists. It provides, for most wildlife species, the nucleus of activity; while other vegetative communities provide only contributing or secondary habitat. This is exemplified by the fact that at least one species using this habitat travels as much as 25 miles daily for food and water.

In the higher elevations, riparian vegetation provides diversity of habitat necessary to support wide varieties of wildlife species. For example, in relatively dense stands of coniferous forests, deciduous riparian conditions provide a variety of plants.

Due to their very nature and location, riparian plants are more subject to loss than nearly any other plant community. Clearing for agricultural purposes, urbanization, road and utility construction, modification of natural drains, and vegetative manipulation has resulted in a direct loss of this habitat. Riparian vegetation has also been lost indirectly through the lowering of the near-surface ground water table. This condition is brought about by direct overdraft pumping or by lowering of streambed elevation through channel construction or naturally through streambed degradation. Lowering of ground water levels also can result from interruption of surface or subsurface water flows. Structural features including reservoirs, flood control structures, irrigation and floodwater diversion structures, and major irrigation canals which have been designed without considering the water regime have such an effect. This limited habitat type needs to be preserved.

The grazing of rangelands by domestic and feral livestock is having far-reaching effects on wildlife productivity. Some species, including the feral burro, are competing directly with wildlife for forage even under moderate stocking rates and with good range conditions. Other species, including cattle, are not presently competing directly with most wildlife. However, when livestock numbers increase to a critical point, range conditions will deteriorate. When the critical point is reached, wildlife carrying capacity is reduced.

A number of activities associated with mining and mineral exploration are destructive to wildlife habitat. The establishment of mineral claims and continued assessment work is resulting in indiscriminate road construction and incidental excavations. Strip and open-pit mining and the resulting overburden deposition is leaving areas barren of vegetation. Runoff from eroding overburden storage areas is causing sediment problems in streams and reservoirs. Mine acid seepage and other chemical effluents have a potential for polluting streams and reservoirs. Continuation of present means and development and application of new means of minimizing the effects of these activities is needed.

Several areas of special biological significance occur within the study area. These areas provide specific conditions which are: (1) favorable to highly concentrated use by one species or type of wildlife, (2) support an unusually high diversity of species, or (3) maintain

populations of extremely rare species. These areas can generally be considered as remnants of conditions which were more widespread during some part of geologic history and are in extremely delicate ecologic balance. These areas should be protected and maintained in their present conditions and not opened to tourism.

SOLID WASTE AND LITTER

Some portions of the study have good solid waste disposal systems whil others have inadequate systems. The sanitary landfill concept of disposal is used extensively as a form of solid waste disposal. However, a few isolated dump sites do exist.

Solid waste disposal problems in Santa Cruz County are severe when compared with those of rural Pima County. At present, five major dump sites and 50 or more "wildcat" dump sites exist within the county. Solid wastes management is carried out on a part-time basis by the County Health Department. The development of area-wide sanitary landfills with salvage operations would be an asset to rural, urban, and recreation areas in the county. Solid waste and litter management in Pinal and Cochise counties is comparable to that in Santa Cruz County.

In the past, there appeared no reason to reuse wastes since virgin materials were abundant and often cheaper than reclaimed materials. However, this view has been replaced because of environmental concerns, shortages, and the feasibility of reclaiming valuable and often irreplaceable resources that form a large part of the discarded solid waste from society. Historically, Americans have operated on the assumption that the earth, water, and air would absorb all the waste products indefinitely. Present calculations and physical indicators show that the earth, the ocean, and the atmosphere are finite, and that nature's capacity to assimilate more waste is decreasing.

The Tucson metropolitan area is the largest producer of solid wastes in the study area. Municipality solid wastes are comprised of the following: (1) residential garbage, (2) residential rubbish, (3) commercial refuse, (4) street refuse, and (5) special waste. Industrial solid wastes are office-type, usually collected by municipal or private solid waste collection entities.

A national EPA survey revealed that less than six (6) percent of the 12,000 land disposal sites in the United States meet minimum federal standards for sanitary landfills. The problem of disposal is aggravated by widespread and increasing use of packaging, "disposable" containers, and other convenience materials that do not burn or decay. EPA estimates that the solid waste load is increasing at twice the rate of population increase.

Tucson's Operations Department is currently operating five sanitary landfills by the cut-and-cover method. Approximately 307,000 tons of refuse were disposed of in Tucson landfills during 1970-71 at a total cost of $186,000 of $0.61 per ton of waste disposed.

The Pima County Department of Sanitation operates two sanitary landfills in which about 70% of the volume of solid waste disposed originates within the city limits of Tucson. About 187,000 tons of waste were disposed of in the county landfills in 1970 at a cost of $257,000 or $1.37 per ton of waste disposed. This unit cost is higher than the city of Tucson because of different accounting methods.

New concepts of solid waste management are evolving; but they assume that man can devise a social-technological system that will wisely control the quantity and characteristics of wastes, efficiently collect those that must be removed, creatively recycle those that can be reused, and properly dispose of those that have no further use.

Alternative solid waste practices that would not disrupt the natural process, the environment, or land conditions should be explored.

AESTHETICS

Natural landscapes have been changed within the study area by roads, railroads, overhead power and communication lines, underground gas and oil pipelines, and abandoned mining areas. Recently, establishment of new housing communities has been a source of disturbance and consequent loss of aesthetic values. As an example, in the area west of Highway 666 between Pearce and Cochise, 20 square miles of one of the finest grassland areas in the state have been divided by eight east-west roads and four north-south roads per square mile. Disturbances of the fine grassland could persist for many years, even if the subdivision fails. Future revegetation will, no doubt, be needed to restore to natural conditions such areas if they are not occupied.

The organization, orderliness, and greenery offered by irrigated agriculture is pleasing to many people. Areas in agricultural production, especially around urban centers, should be maintained in that use.

ARCHEOLOGICAL AND HISTORICAL RESOURCES

Man needs to know his past development in order to assess the present and plan for the future. For instance, the ancient Hohokam Indian Civilization which depended largely on irrigated agriculture for their livelihood, once flourished in part of the study area. Although the civilization vanished, they left a well developed network of irrigation canals on which much of today's modern-day system is based. The disappearance of the civilization could have been related to irrigation problems. If these problems were presently known, the present civilization would be in a better position to evaluate its situation and take measures to prevent the same problems from arising.

Other more recent historical developments need to be preserved to make our past more alive and vivid. People can better relate to a way of life in another era if they see a preserved site, rather than merely read a description as seen by someone else. As the demand for recreation increases, a number of these historical sites will need to be developed as tourist attractions.

A list of historical and archeological sites which are important enough to be considered as having potential for inclusion in the National Register of Historic Places is exhibited in Table 5.14. These sites and others already listed in the register need to be preserved.

TABLE 5.14

HISTORICAL AND ARCHEOLOGICAL SITES
FOR POTENTIAL INCLUSION IN THE NATIONAL
REGISTER OF HISTORIC PLACES,
SANTA CRUZ-SAN PEDRO RIVER BASINS

Name of Area	County	Location and Year Established
Alamo Canyon	Pima	North of Tucson
Arivaca	Pima	West of Tumacacori National Monument, ca. 1733
Arizona Narrow Gage Railroad	Pima	North of Tucson
Armory Park District	Pima	Tucson
Barrio Historico	Pima	Tucson
Bowley State Station	Pima	Robles Junction vicinity, ca. 1883
Canada del Oro	Pima	North of Tucson, ca. 1862
Canao Ranch Site	Pima	Continental vicinity, ca. 1775, 1860
Cerro Colorado	Pima	Arivaca vicinity, ca. 1856
Children's Shrine	Pima	Papago Indian Reservation near Santa Rosa, date unknown
Cienaga Springs Station	Pima	Pantano vicinity, ca. 1858
Cocorague Butte Archeological Site	Pima	24 mi. West of Tucson
Colossal Cave	Pima	22 mi. SE of Tucson
Davis Ruin	Pima	Redington Road vicinity, ca. 12-14th Century
Fish-Stevens House	Pima	Tucson
Freeman Homestead	Pima	14 mi. SE of Tucson
Greaterville (Ghost Town)	Pima	35 mi. South of Tucson, ca. 1875

TABLE 5.14

(Continued)

Name of Area	County	Location and Year Established
Gu Achi	Pima	Gu Achi, Papago Reservation ca. 1698 (Kino)
Gu Achi Archeological District	Pima	65 mi. West of Tucson
Heintzleman Mine	Pima	Arivaca, ca. 1858
Helvetia	Pima	East of Continental, ca. 1890
Sam Hughes House	Pima	Tucson
Fort Lowell	Pima	Tucson, ca. 1873
Kitt Peak National Observatiory	Pima	42 mi. SW of Tucson, ca. 1958
Matty Canyon	Pima	Matty Canyon & Cienega
Military Plaza	Pima	Tucson, ca. 1866
Mineral Hill	Pima	18 mi. South of Tucson, ca. 1920
Mission of Guadalupe	Pima	Tucson
Mission Santa Ana del Chiquiburitar	Pima	48 mi. West of Tucson
Olive	Pima	20 mi. South of Tucson, ca. 1880's
La Osa Ranch	Pima	Sasabe vicinity, ca. 1885
El Paso and Southwestern Railroad Depot	Pima	Tucson
Pasqua Village	Pima	Tucson, ca. 1900
Patterson House	Pima	Tucson
Picture Rocks	Pima	Cortaro vicinity, ca. unknown
Pit House of Tucson	Pima	Tucson
Posta Quemada Canyou Site	Pima	Vail vicinity, ca. 1875

TABLE 5.14

(Continued)

Name of Area	County	Location and Year Established
Presidio de Tucson Site	Pima	Pima County Courthouse, ca. 1776
El Prisidio District	Pima	Tucson
Quijotoa	Pima	70 mi. West of Tucson
Redington State Stop	Pima	Rincon Mountains, ca. 1858
Reeve Ruin	Pima	Redington Road vicinity, ca. 14th Century
Rosemont	Pima	30 mi. SE of Tucson, ca. 1870's
Saguaro National Monument Lime Kiln	Pima	15 mi. East of Tucson
Sahuarita	Pima	South of Tucson on State Highway 89, ca. 1879
St. Mary's Hospital	Pima	Tucson
San Augustine del Tucson	Pima	Tucson
San Jose del Tucson Mission Site	Pima	Congress St. and Santa Cruz River, Tucson, ca. 1775
Silverbell	Pima	36 mi. West of Tucson, ca. 1904
Second Territorial Capitol Site	Pima	Ochoa St., Tucson, ca. 1868
Solomon Warner House and Mill	Pima	Tucson
Temple Emanu El	Pima	Tucson
Total Wreck	Pima	32 mi. SE of Tucson, ca. 1877
Tucson Magnetic Observatory	Pima	Tucson
Twin Buttes	Pima	23 mi. South of Tucson
Valley of the Moon	Pima	Tucson

TABLE 5.14

(Continued)

Name of Area	County	Location and Year Established
Theodore Welish House	Pima	35 mi. South of Tucson
Adamsville	Pinal	West of Florence, ca. 1870
American Flag Ranch Headquarters	Pinal	26 mi. North of Tucson, ca. 1882
AZ AA:5:52	Pinal	12 mi. South of Casa Grande
AZ Z:4:6	Pinal	18 mi. West of Casa Grande
Blackwater state Station Site	Pinal	Sacaton vicinity, ca. 1875
Blue Water Site	Pinal	East of Casa Grande, ca. 1862
Casa Blanca Ruins	Pinal	West of Bapchule on Santa Cruz River
Copper Creek	Pinal	47 mi. NE of Tucson near Mammoth, ca. 1863
Brunenkant Building	Pinal	Florence
Clandestine Smelter	Pinal	Florence, ca. 1890
William Clarke House	Pinal	Florence
Clemens House	Pinal	Florence
Collingwood House	Pinal	Florence
Pauline Cushman House	Pinal	Florence
E.N. Fish Store	Pinal	Florence
Florence Hotel	Pinal	Florence
Japanese Relocation Center at Rivers	Pinal	15 mi. NW of Casa Grange near Sacaton
Lucal Leos House	Pinal	Florence
Maricopa Wells Site	Pinal	28 mi. NW of Casa Grande near Maricopa

TABLE 5.14

(Continued)

Name of Area	County	Location and Year Established
Mountain View Hotel	Pinal	Oracle, 30 mi. North of Tucson
Olberg Petroglyphs	Pinal	14 mi. North of Casa Grande
Old Camp Grant (Camp Breckenridge)	Pinal	North of Mammoth, ca. 1871
Oneida Stage Station Site	Pinal	Casa Grande vicinity, ca. 1858
Peralta Rock Site	Pinal	29 mi. NW of Casa Grande near Maricopa
Picacho Pass, Peak	Pinal	Picacho vicinity, ca. 1846, 1862
Picacho Petroglyph Site	Pinal	25 mi. SE of Casa Grande
Pinal County Courthouse (Second)	Pinal	Florence
First Presbyterian Church of Florence	Pinal	Florence
First Ruggles House	Pinal	Florence
Flieger Site	Pinal	Aravaipa Creek vicinity, ca. AD 900
Sacaton Experimental Farm	Pinal	15 mi. North of Casa Grande near Sacaton
Sacaton Itaglio	Pinal	15 mi. North of Casa Grande near Sacaton
Sacaton Station	Pinal	Sacaton, ca. 1859
Sasco	Pinal	30 mi. SE of Casa Grande near Redrock, ca. 1907
Tiger	Pinal	38 mi. NE of Tucson near Mammoth, ca. 1939
Tom Mix Wash	Pinal	Pinal Pioneer Parkway, ca. 1946

TABLE 5.14

(Continued)

Name of Area	County	Location and Year Established
Vekol	Pinal	30 mi. SW of Casa Grande, ca. early 1880's
John D. Walker House	Pinal	Florence
White Apartments	Pinal	Florence
Arnold Hotel	Cochise	Benson
Babocomari Site	Cochise	Fairbank vicinity, ca. 1835
Benson Depot	Cochise	Benson
Benson School Bus	Cochise	Benson
Benson Smelter Ruin	Cochise	Benson
Old Benson Cemetery	Cochise	Benson
Rirdcage Theater	Cochise	Tombstone
Brewery Gulch	Cochise	Bisbee Area, ca. 1880
Camp John A Rucker	Cochise	26 mi. East of Courtland, ca. 1879
Cima Cabin	Cochise	Near Chiricahua Peak in Coronado National Forest
Charleston Site (Ghost Town)	Cochise	Tombstone vicinity, ca. 1880
Cochise Hotel	Cochise	Cochise, SE of Willcox
Cochise West Stronghold	Cochise	Dragoon vicinity, ca. 1860
Commonwealth Mine	Cochise	Pearce vicinity, ca. 1894
Contention City (Ghost Town)	Cochise	14 mi. South of Benson near Boquillas, ca. 1880
Copper Queen Hotel	Cochise	Bisbee area, ca. 1898
Council Rocks	Cochise	Dragoon vicinity, ca. 1872
Courtland (Ghost Town)	Cochise	16 mi. East of Tombstone, ca. 1909

TABLE 5.14

(Continued)

Name of Area	County	Location and Year Established
Dos Cabezas	Cochise	14 mi. SE of Willcox, ca. 1851
Douglas Municipal Ariport	Cochise	Douglas
Dragoon Springs Stage Station	Cochise	16 mi. East of Benson, ca. 1858
Duncan Hotel	Cochise	Willcox
Fairbank	Cochise	18 mi. South of Benson, ca. 1883
Gadsden Hotel	Cochise	Douglas
Galeyville (Ghost Town)	Cochise	Chiricahua Mountains, ca. 1880
Garces	Cochise	22 mi. West of Bisbee, ca. 1901
Garden Canyon Archeological Site	Cochise	Fort Huachuca
George Warren Grave	Cochise	Bisbee, ca. 1892
Gleeson (Ghost Town)	Cochise	14 mi. East of Tombstone, ca. 1890
Hamburg	Cochise	26 mi. West of Bisbee, ca. 1906
Iron Front Building	Cochise	Willcox, ca. 1900
Johnson	Cochise	17 mi. SW of Willcox, ca. 1900
Kent Court	Cochise	Douglas
Lavender Pit Mine	Cochise	Bisbee area, ca. 1950
Lucky Cuss Mine	Cochise	Tombstone
Middlemarch	Cochise	27 mi. South of Willcox near Pearce, ca. 1898
Millville	Cochise	24 mi. South of Benson, near Charleston

TABLE 5.14

(Continued)

Name of Area	County	Location and Year Established
Montezuma School House	Cochise	18 mi. SW of Bisbee
Naco Kill Site	Cochise	Naco vicinity, ca. 8000 BC
John H. Norton Commercial Co.	Cochise	Willcox
Ohnesorgen Stage Station Site	Cochise	Benson vicinity, ca. 1870
Pearce (Ghost Town)	Cochise	24 mi. South of Willcox, ca. 1896
Peck Home	Cochise	Willcox
Point-of-Mountain Stage Station Site	Cochise	Willcox vicinity, ca. 1874
Reform School Gymnasium	Cochise	Benson
Russelville	Cochise	18 mi. SW of Willcox
Sacred Heart Church	Cochise	Tombstone
Schieffelin Hall	Cochise	Tombstone
Schwertner-Nordhus House	Cochise	Willcox
Soza Ranch	Cochise	28 mi. North of Benson
Steele's Station	Cochise	14 mi. South of Benson near Boquillas
Sunnyside (Ghost Town)	Cochise	30 mi. West of Bisbee, ca. 1880's
Tres Alamos Archeological District	Cochise	7 mi. West of Bisbee, ca. 1880's
Turquoise	Cochise	14 mi. East of Tombstone, ca. 1890
Willcox Bank and Trust Company	Cochise	Willcox

TABLE 5.14

(Continued)

Name of Area	County	Location and Year Established
Willcox Lumber Yard	Cochise	Willcox
Aravaipa Archeological District	Graham	56 mi. NW of Willcox near Klondyke
Fort Grant	Graham	Fort Grant, ca. 1872
Aleso Springs	Santa Cruz	20 mi. North of Nogales near Carmen
Baca Float No. 3	Santa Cruz	Tumacacori vicinity, prior to 1830
Fort Buchanan Site	Santa Cruz	Patagonia vicinity, ca. 1856
Buena Vista Land Grant	Santa Cruz	Nogales vicinity, ca. 1831
Calabasas Site	Santa Cruz	Tumacacori vicinity, ca. 1850
Camp Cameron Site	Santa Cruz	East of Tubac, ca. 1866
Canelo Hills Cienega	Santa Cruz	30 mi. NE of Nogales near Canelo
Fort Crittenden Site	Santa Cruz	Sonoita vicinity, 1867
Garrett Ranch House	Santa Cruz	20 mi. North of Nogales near Tubac
Harshaw (Ghost Town)	Santa Cruz	16 mi. NE of Nogales, ca. 1880
Camp Stephen D. Little Site	Santa Cruz	Nogales, ca. 1915
Lochiel	Santa Cruz	19 mi. East of Nogales, ca. 1882
Madera Canyon Sawmill Site	Santa Cruz	24 mi. North of Nogales
Maria Santissima del Carmen Land Grant	Santa Cruz	8 mi. East of Nogales
Camp McKee (Ft. Mason) Site	Santa Cruz	Vicinity of Tumacacori, ca 1856, 1865

TABLE 5.14

(Continued)

Name of Area	County	Location and Year Established
Mowry Mine	Santa Cruz	South of Patagonia, ca. 1858
Noonville	Santa Cruz	10 mi. West of Nogales, ca. 1887
Oro Blanco	Santa Cruz	25 mi. West of Nogales, ca. 1879
Patagonia Railroad Station	Santa Cruz	Patagonia, ca. 1900
Peck Canyon	Santa Cruz	Tumacacori vicinity, ca. 1880
Salero Mine	Santa Cruz	Tubac vicinity, ca. 17th Century
Santa Cruz County Courthouse	Santa Cruz	Nogales, ca. 1930
Santa Rita Hacienda	Santa Cruz	27 mi. North of Nogales
Sonoita	Santa Cruz	Sonoita, ca. 1860
Sopori Ranch Site	Santa Cruz	Amado vicinity, ca. 1850
Tubac	Santa Cruz	Tumacacori vicinity, ca. 18th Century - 1858
Otero School House	Santa Cruz	ca. 1840
Presidio Site	Santa Cruz	ca. 1752
Old Mill Site	Santa Cruz	unknown
St. Ann's Church and Site	Santa Cruz	ca. 18th Century - 1930
Yoas' House	Santa Cruz	19th Century
Johnny Ward's Ranch Site	Santa Cruz	Patagonia vicinity, ca. 1860
Washington Camp	Santa Cruz	16 mi. East of Nogales at Duquesne, ca. 1880

Primary Source: Arizona State Parks Department

CHAPTER 6

EXISTING WATER AND RELATED LAND RESOURCE PROJECTS AND PROGRAMS

SOIL CONSERVATION (SCS)

Public Law 46

Public Law 46 was passed by the 75th Congress in 1935. The act formally recognized soil erosion as "a menace to national welfare" and declared as "policy of Congress to provide permanently for the control and prevention of soil erosion and thereby to preserve natural resources, control floods, prevent impairment of reservoirs, and maintain the navigation of rivers and harbors, protect public health, public lands..." The Soil Conservation Service (SCS), organized as a result of this law, provides technical assistance to farmers, ranchers, and other land administrators such as landowners, communities, and institutions in planning, applying, and maintaining soil and water conservation on their lands.

Most of the work accomplished by SCS techincal assistance is carried out through local natural resource conservation districts. Related activities of SCS include soil surveys and interpretations, propagation of new conservation plant materials, and technical assistance in connection with other USDA programs. PL-566 watershed projects are initiated through the PL-46 program and natural resource conservation district activities.

SCS has become involved in environmental improvement as a result of its activities in soil and water conservation. Reductions of soil erosion results in lower sediment concentrations in streams and lakes. The SCS is actively involved in feedlot design to reduce water pollution. The soil surveys which the SCS conducts provide information to local officials or planning boards, to developers and engineers, and to others engaged in regional and community planning and development. Those who use this data can determine if the planned land use is compatible with soil conditions, landscape, flood hazard, and other limitations.

Resource Conservation and Development Projects

Under the Food and Agriculture Act of 1962, the U.S. Department of Agriculture, with Soil Conservation Service providing leadership, gives technical and financial assistance to local groups in resource conservation and development projects (RC&D). These rural-urban projects are locally initiated, sponsored, and directed. They provide local groups the opportunity to coordinate and use federal, state, and local programs. The goals of RC&D are to develop, improve, conserve, and use the natural resources for economic improvement and enhancement of the environment and standard of living.

All of Cochise, Graham, and Santa Cruz Counties are in the Coronado Resource Conservation and Development Project area.

Public Law 566

In 1954, the United States Congress passed the Watershed Protection and Flood Prevention Act (PL-566) to help local units of government protect rural communities and rural lands. The Act authorizes the Secretary of Agriculture to cooperate with cities, towns, counties, flood control districts, and other local units of government in the planning and construction of vegetative and structural measures for land treatment, flood prevention, irrigation, drainage, recreation, fish and wildlife, municipal and industrial water supply, and water quality control. Under the Act, sponsoring local governments can plan, construct, operate, maintain, and administer projects. PL-566 projects are federally assisted projects rather than federal projects. The Soil Conservation Service, acting on behalf of the Secretary of Agriculture, provides both technical and financial assistance to the sponsors.

The PL-566 provides for a project-type approach to soil and water resource development, use, and conservation. It requires that full initiative and maximum responsibility for any project be exercised by local people through their local organizations. It encourages the close cooperation and assistance of state agencies and emphasizes the partnership of local, state, and federal agencies in achieving the purposes of the projects.

The PL-566 program has proven very popular and effective in Arizona, although projects built to date have only included land treatment and flood prevention. There are no completed projects nor any construction underway in the study area at the present time.

Public Law 84-1021

The Great Plains Conservation Program is authorized by Public Law 84-1021 and administered by the USDA, Soil Conservation Service. This program provides cost sharing of approved practices outlined in a soil and water conservation plan. The conservation plan is developed by the landuser with assistance from the SCS through Natural Resource Conservation Districts and is a legal contract that assures the application and maintenance of measures to protect the natural resources. This program is approved only in the Great Plains States, but a similar program may be needed to accelerate projected land treatment programs in this study area.

NATURAL RESOURCE CONSERVATION DISTRICTS (NRCD's)

Natural Resource Conservation Districts (NRCD's) are entities of state government organized by local referendum under provisions of state law. They are directed by local boards of supervisors elected by the owners of lands lying within the district. They provide local programs of resource planning, development, and utilization, and furnish a means for individual citizens and organized groups to participate in

the planning, spread, and installation of soil and water conservation practices needed to protect and improve the land, water, and related resources.

Their programs are largely carried out with technical assistance furnished by the Soil Conservation Service under memoranda of understanding. Other federal and state agencies participate in carrying out district objectives.

NRCD's in the Santa Cruz-San Pedro study area have no taxing authority or power of eminent domain. Financing is met by limited appropriations of county and state governments and through the support of individual landowners. Districts serve as co-sponsors for all approved PL-566 watershed projects in the study area. Their responsibility in development of these projects is primarily to carry out the land treatment phase of the work plans. Districts initiate and assist the people in watersheds to organize flood control districts.

All of the study area is covered by districts. Those which lie completely within the study area are Hereford, San Pedro, and Redington; and those which are partially in the area are Pima, West Pinal, East Maricopa, Florence-Coolidge, Eloy, Winkelman, Gila Valley, Willcox-San Simon, and Whitewater Draw.

FLOOD CONTROL DISTRICTS

Flood control districts are special purpose entities of counties. The counties, through enabling state legislation, have the authority to approve flood control districts. Their purpose is to develop and execute plans and programs relating to any phase of conservation of water, water usage, flood prevention and control, erosion prevention and control, and floodwater and sediment damages. They are the primary local sponsoring authority for watershed projects developed under Public Law-566, since they have the power of eminent domain and to levy taxes.

AGRICULTURAL STABILIZATION AND CONSERVATION SERVICE (ASCS)

The Agricultural Stabilization and Conservation Serivce (ASCS) is an agency of the United States Department of Agrigulture which administers programs designed to stabilize the Nation's agricultural economy, conserve farm resources, and protect food and feed reserves. The ASCS programs concerned with conservation of resources have some aspects which involve planned or group action.

The Agricultural Conservation Program (ACP) is designed to share with farmers and forest landowners from 50 to 75 percent of the cost of carrying out approved forestry and conservation practices. Practices applicable in the study area, offered under the 1974 RECP for annual or long-term agreements, includes establishing permanent vegetative cover; improving permanent vegetative cover, water

impoundment reservoirs; diversions, streambank stabilization; sediment retention; erosion or water control structures; sediment, chemical or water runoff control measures; windbreaks or shelterbelts; and reorganizing irrigation systems. All were designed to provide enduring protection to soil and water resources. In addition, state and county committees were given the opportunity to develop, with appropriate justification, other practices needed to solve critical local conservation problems. Two practices developed under this authority were underground barriers to prevent erosion and development of livestock water.

Under the long-term agreements, essential practices and practice cost-sharing is scheduled over a period of three to ten years. These agreements with farmers are based on whole farm conservation plans which have been approved by appropriate officials.

Farmers may participate individually, or two or more may participate in pooling agreements on projects that will provide common benefit to their land or to the overall neighborhood. For example, a number of farmers in a watershed may combine efforts to reduce erosion or eliminate other forms of pollution, thus enhancing recreational or other environmental benefits for the community at large.

FARMERS HOME ADMINISTRATION (FmHA)

The Farmers Home Administration (FmHA), an agency of the U.S. Department of Agriculture, provides a supplemental source of supervised credit augmenting the efforts of the private lenders rather than competing with them. Most FmHA programs require that a borrower "graduate" to commercial credit when able to do so. The nature of the agency's operation makes it possible for Farmers Home Administration to increase the supply of rural credit by drawing money from the major finance centers of our nation.

Most of the loan programs are either guaranteed or insured. Guaranteed loans are those in which the loan is made and serviced by a private lender. FmHA guarantees to limit any loss to a specified percentage. Interest rates are determined between borrower and lender unless the rate is established by law.

Insured loans are originated, made, and serviced by the personnel of the agency. Notes are sold to investors, backed by the full faith of the U.S. Government, and the investor's money replenishes a revolving loan fund. For most programs, interest rates to borrowers are determined by the current cost of federal borrowing; although some rates are established by statute.

The different types of loans, types of borrowers, and purposes of loans are exhibited in Table 6.1.

TABLE 6.1--TYPES, BORROWER, AND PURPOSE OF LOANS MADE BY THE FARMERS HOME ADMINISTRATION

Type of Loan	Type of Borrower	Purpose
Farmer Loans		
Farmer Ownership Loans	Resident, family size operation. Operating farm at least part time. Substantial share of income provided by farm	Buy land. Refinance debts. Construct or repair buildings. Improve farm lands. Develop water facilities. Establish farm based business enterprises to supplement farm income.
Farm Operating Loans	Same as ownership loans	Buy livestock, equipment, feed seed, fertilizer, birds, or supplies for farm and home operation. Refinance debts and pay interest on debts. Make minor real estate improvements. Improve forest lands. Establish non-farm enterprise to supplement farm income.
Farm Emergency Loans	Same as ownership loans	For needs to restore normal farm operation after severe loss from natural disaster in designated areas.

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(Table 6.1 Cont'd)

Type of Loan	Type of Borrower	Purpose
Soil and Water Conservation Loans	Individuals, partnerships, or corporations with qualifications as in ownership loans	Development of land and water forestation, drainage and irrigation of farmland, pasture improvement, and related land and water use adjustment.
Grazing Association Loans	Nonprofit corporations, owned, operated, and managed by neighboring family farms	Acquire and develop grazing lands for livestock of association members.
Indian Land Acquisition Loans	Qualified tribes or tribal corporations	Buy land within reservations.
Irrigation and Drainage Loans	Public agencies and nonprofit corporations	Develop community irrigation drainage and other soil and water conservation use facilities.
Resource Conservation Loans	Public agencies and nonprofit corporations	Conserve and develop natural resources in areas designated by the Soil Conservation Service.
Watershed Loan	Authorized agencies	Installation of flood control dams, reservoirs, irrigation canals, easements, and other structures.
Recreation Enterprise Loans	Eligible farmer	Develop income producing recreation areas.

(Table 6.1 Cont'd)

Type of Loan	Type of Borrower	Purpose
Housing Loans	Families of low or moderate income residing in rural areas or towns of 10,000 or less.	Buy, build, or repair homes for their own use or build rental units for people 62 years or older or for low to moderate income families.
Community Facility Loans	Public agencies or nonprofit corporations	Construct community facilities such as water and waste disposal systems, meeting centers, fire stations, and others.
Business and Industrial Loans	Eligible legal entities in open country or towns up to 50,000 people.	Develop and finance business or industry, increase income or employment, control or abate pollution.

COOPERATIVE STATE-FEDERAL FORESTRY PROGRAMS

Arizona's participation is State-Federal cooperative forestry programs was initiated in 1966 with passage of H.B. 162, during the Second Session of the Twenty-Seventh Legislature. Legislation assigned the duties of State Forester to State Land Commissioner, Obed M. Lassen. Being closely allied to established watershed activities, the Division of Watershed Management in the State Land Department became the Division of Watershed and Forestry. The Forestry Division was given its separate identity on 1971 when watershed management activities were transferred from the State Land Department to the newly renamed and reconstituted Arizona Water Commission.

Cooperative fire control and protection for state and private lands are provided by Section 2 of the Clark-McNary Act of 1924. Under the cooperative fire control program, fire districts and fire associations have been formed; volunteer firefighters have been trained; and fire-fighting equipment has been supplied from excess federal property. As related to fire district organizations, 33 percent of the state owned land in the study area is in Cochise County, 30 percent is in Pinal County, 27 percent in Pima County, and the remaining 10 percent is in Graham, Santa Cruz, and Maricopa counties.

Cooperative distribution of trees through the State Forester is made possible by Section 4 of the Clark-McNary Act. Seedlings of conifer and hardwood trees are made available to landowners at cost during the spring planting season. Trees are made available for planting in shelterbelts, windbreaks, forests, and Christmas tree plantations. The initial distribution of trees to counties in the study area was made in 1974 as follows:

County	Number of Trees	Percent of State Total
Cochise	15,650	12.4
Pima	2,250	1.8
Pinal	4,800	3.8
Santa Cruz	3,100	2.5
Graham	1,650	1.3
TOTAL	27,450	21.8

The Agricultural Act of 1956 (Title I) provides the basis for the State Forestry Division to cooperate with the Forest Service, U.S. Department of Agriculture, in making technical assistance available to private landowners participating in the conservation programs of the County Agricultural Stabilization and Conservation committees. In this program, the State Forester provides technical guidance in tree planting and timber stand improvement techniques. The State Forester must approve prepared management plans and certify satisfactory completion of projects before cost-share payments can be made by the County ASCS office. This program encourages good management of private timber lands. The State Forester also cooperates in the Rural Environmental Conservation Program.

The Forestry Division of the State Land Department provides technical assistance to the Coronado Resource Conservation and Development Project, much of which lies within the Santa Cruz-San Pedro River Basins.

The State Forestry Division in Arizona makes use of the Forest Pest Control Act of 1947 in controlling infestations of forest insects and epidemics of forest diseases with federal cooperation.

NATIONAL FOREST DEVELOPMENT AND MULTIPLE USE PROGRAMS

The Coronado National Forest, as it exists today, was formed by consolidations of a number of separate units that were mainly set aside between 1902 and 1920. The Santa Rita, Santa Catalina, and Chiricahua Forest Reserves were established in 1902 under the Creative Act of March 3, 1891 and the Organic Administration Act of June 4, 1897. These Forest Reserves predated the Transfer Act of February 1, 1905, which transferred management of forest resources to the Secretary of Agriculture.

Management of the Coronado National Forest Ranger Districts is guided principally by the Multiple Use-Sustained Yield Act of June 12, 1960. Multiple use aspects of this act provide coordinated management for outdoor recreation, range, timber, watersheds, wildlife, and fish.

Preservation and enhancement of aesthetic values is one of the major goals of the Coronado National Forest even where large tracts of land are subjected to more than one use. Maintenance of natural features in high elevation conifer forests, intermediate woodland-chaparral (oak woodlands, pinyon-juniper woodlands, and chaparral), desert grassland, and low elevation Chihuahuan and Sonoran desert types has been an aim in the management of Coronado National Forest lands. Enhancement, preservation, and minimum alteration of natural features are major considerations in such forest management activities as control of wildfires; harvest of forest products; regulated grazing use; location and construction of roads and trails; design, location, and erection of camp and picnic grounds; regulated disposal of garbage and human waste; restoration of past mining disturbance and regulation of new mining activities; and preservation of two wilderness areas, two natural areas, and numerous fenced study plots.

A number of legislative acts passed by Congress are directed to satisfy more specific management needs. The Forest Pest Control Act of June 25, 1947, provides for organizing cooperative efforts to prevent, control, suppress, or eradicate emergency outbreaks of destructive insects and diseases. The Flood Control Act of June 28, 1938, provides a means of safeguarding lives and property against destructive floods, erosion, and sedimentation that result when watersheds are swept by wildfires or devastating storms.

Preservation of the Chiricahua and Galuiro Wilderness areas has been assured by the Wilderness Act of September 3, 1964. The Land and Water Conservation Fund Act of September 3, 1964, has provided direction towards upgrading the quality and quantity of outdoor recreation resources and facilities.

The National Environmental Policy Act of 1969 (NEPA) encourages the continued enhancement and protection of environmental quality characteristic of national forest lands.

Protection of water sources against pollution as required by the Environmental Improvement Act of 1970 has caused improvement in the methods of disposing of waste from camp and picnic areas.

The Watershed Protection and Flood Prevention Act of August 4, 1954 provides a potential means of treating national forest lands to prevent damages from erosion, flooding, and sedimentation, and to enhance the conservation, development, utilization, and safe discharge of water. This is particularly significant in the study area because the Coronado National Forest includes the major high elevation watersheds where greater rainfall occurs.

Under the McSweeney-McNary Forest Research Act of May 22, 1928, research activities of the Tucson Branch of the Rocky Mountain Forest and Range Experiment Station have been underway at the Santa Rita Experimental Range. Research on this experimental range predates the McSweeney-McNary Act, since this area, established in 1902, was one of the first reserves. Cooperative research with the states in resource management, control of destructive agents, and utilization of forest products is made possible by the Assist States in Program of Forestry Research Act of October 10, 1962, which assists states in programs of forestry research. Some cooperative research has been carried out by the University of Arizona under this Act.

The Forest and Rangeland Renewable Resources Planning Act of 1974, directs that long-range plans be developed to insure that the United States has an adequate supply of renewable resources from the Nation's 1.6 billion acres of public and private forests and rangelands while maintaining the integrity and quality of the environment.

MAJOR WATER RESOURCE DEVELOPMENT PROJECTS AND STUDIES

Flood Control

Several agencies are responsible for assisting local organizations in solving flood problems. Following is a discussion of the agencies with such responsibilities, their authorities, and the existing and proposed projects and studies within the study area.

Corps of Engineers (CE)

The Corps of Engineers, Department of the Army, is responsible for the administration of the water resources programs of the Department of Defense. Among other activities, the work includes planning and constructing flood control and multiple-purpose projects, constructing emergency bank protection works to prevent flood damage to public works, snagging and clearing of stream channels in the interest of flood control, fighting floods, making emergency repairs, compiling and disseminating information on floods and flood damage potentials, and cooperating with the Department of Housing and Urban Development in the National Flood Insurance Program by furnishing information on frequency of flooding and extent of flood damages.

Following is a tabulation showing existing and authorized Corps of Engineers flood control and prevention measures in the study area:

Flood Control Reservoirs (Constructed)

Tat Monolikot (Lake St. Clair) on Santa Rosa Wash

Levees and Channels (Constructed)

Tucson Diversion
Greens Wash Levee on Greens Wash

Levees and Channels (Authorized)

Middle Gila

Flood Plain Information Studies (Completed)

Santa Cruz River (State Hwy. 82 to International Boundary)
Santa Cruz River (Vicinity of Sonoita Creek)
Rillito Creek
Pantano Wash
Tanque Verde Creek

Flood Insurance Studies (Completed)

Willcox
Bisbee

Bureau of Reclamation (BR)

The major responsibilities of the Bureau of Reclamation, U.S. Department of the Interior, involve planning, designing, constructing, operating, and maintaining works for storage, diversion, and development of waters for irrigating arid and semi-arid lands in the western states. The Reclamation Act of 1939, however, provides for inclusion of flood control allocations in Bureau of Reclamation projects. The Act of December 22, 1944, provides for cooperation between the Secretary of the Interior and the Chief of Engineers, Corps of Engineers, in the investigation and development of flood control on Bureau of Reclamation

projects. The Bureau of Reclamation also provides assistance to existing irrigation projects suffering from natural disasters such as major floods. Bureau of Reclamation proposed measures within the study area which include flood control are the authorized Charleston Dam on the San Pedro River and Buttes Dam on the Gila River. Both are authorized features of the Central Arizona Project.

Geological Survey (GS)

The responsibilities of the Geological Survey (GS), U. S. Department of the Interior, include the determination of the source, quantity, quality, distribution, movement, and availability of both surface and ground water. Investigations of floods and droughts are part of these responsibilities. Flood-prone area studies have been carried out by the GS on the Santa Cruz River, Sant Rosa Wash, Brawley Wash, Rillito Creek, and Pantano Wash. Flood insurance studies are being conducted by the GS for Tucson, South Tucson, Oro Valley, Casa Grande, and the unincorporated areas of Pima County.

Water Supply

Central Arizona Project (CAP)

The Central Arizona Project will facilitate the importation of Colorado River water to central Arizona. This will be a giant step toward reducing the annual overdraft causing ground water levels to decline as much as eight to ten feet per year in some areas. Primary responsibility for project planning has been with the Bureau of Reclamation, U. S. Department of Interior. The Central Arizona Water Conservation District has been established as a master contracting entity for most project water delivered to non-Indian users. By contract with the Secretary of the Interior, the District has assumed a repayment obligation of up to $1.2 billion associated with such deliveries.

The project will provide supplemental water for established agricultural areas in Maricopa, Pinal, and Pima counties, as well as, municipal and industrial water for the rapidly expanding metropolitan areas of central Arizona. Other water deficient areas of Arizona and western New Mexico will also benefit from the project under the water exchange principle. In addition, the project will provide substantial benefits from flood control, outdoor recreation, fish and wildlife conservation, and sediment retention. The project as authorized has the capacity to divert 3,000 cubic feet per second from the Colorado River. It will deliver an estimated average of 1,200,000 acre-feet of water per year during the 50-year project repayment period.

Planned project facilities located in the Santa Cruz-San Pedro River Basins include Reaches 4 and 5 of the Salt-Gila Aqueduct, the Tucson Aqueduct, pumping plants, and Charleston Dam and Reservoir. The Salt-Gila Aqueduct enters the study area by means of a siphon across the Gila River located approximately four miles downstream from Ashurst-Hayden Dam. The exact capacities of the two reaches of the aqueduct have not yet been determined.

The Tucson Aqueduct will originate at the terminus of the Salt-Gila Aqueduct near Marana and will convey water through a 30-mile pressure pipeline to a proposed reservoir to be located in the Tucson Mountains west of Tucson. Water from this reservoir will be available to serve the municipal and industrial needs of the city of Tucson and the needs of various communities and mining companies located south of Tucson.

Charleston Dam, a planned multipurpose storage facility, will be constructed on the San Pedro River in Cochise County about 65 miles southeast of Tucson to provide conservation and flood control capacity. The water to be supplied from the reservoir was originally intended for municipal and industrial uses in Tucson. This dam, although authorized as a part of the Central Arizona Project, may never be constructed because of national funding priorities.

Irrigation Districts Projects

Irrigation districts are organized by law for the purpose of providing water, storage facilities, and delivery systems for the irrigation of lands. Irrigation districts are public, political, taxing subdivisions of the State and are vested with all the rights, privileges, and benefits granted municipal corporations and political subdivisions.

Formation of a district requires a formal petition from a majority of property owners within the boundaries of the proposed district. The petition must be presented to the appropriate county board of supervisors. After a public hearing, property owners either accept or reject the proposed organization. On the organizational ballot, the voters may elect to include drainage powers as part of the district functions. As used herein, drainage pertains to the process of relieving lands of excess water and salt.

Powers of management are vested in the board of directors chosen by the electors. The board is limited to the amount the district may be bonded by the wishes of the electorate.

The following is a list of districts located within the study area:

Irrigation Districts

Flowing Wells
Cortaro-Marana
Santa Cruz
St. David

Irrigation and Drainage Districts

Hohokam
Maricopa-Stanfield
San Carlos
Central Arizona
Silverbell

Irrigation Projects on Indian Trust Lands

Gila River Indian Reservation
  San Carlos Indian Irrigation Project
Papago Indian Reservation
  Chuichu
  Vaiva Vo (Proposed)
San Xavier Indian Reservation
Ak Chin (Maricopa) Indian Reservation

Ground water is the primary source of irrigation water in the study area, but major surface water diversion of the Gila River occurs at the Ashurst-Hayden Diversion Dam for irrigation of lands in the San Carlos Irrigation and Drainage District and the San Carlos Indian Irrigation Project. Other minor surface-water diversions occur upstream along the San Pedro River.

STATE DEVELOPMENT FOR RECREATION, FISH, AND WILDLIFE

Recreation

The State Parks Department was established comparatively recently. Therefore, land acquisitions by the State for recreation purposes are equally recent. State parks within the study area are: Tombstone Courthouse, a Victorian structure dating back to the 1880's; Tubac Presidio, a historical museum, 45 miles south of Tucson, covering a 280-year period of Spanish and Mexican influence; and Picacho Peak 35 miles northwest of Tucson, which is near the site of Arizona's only Civil War battle and is managed for hiking, camping, nature study, and relaxation.

Fish and Wildlife

In 1929, Arizona established a Department of Conservation to enforce laws and do the countless other jobs which had evolved as a part of fish and game management. The Commissioners became an advisory, policy-making group.

In 1937, federal monies became available to the states for use on wildlife restoration projects through the Federal Aid in Wildlife Restoration Act; also known as the Pittman-Robertson Act. This act provides federal aid through funds derived from an excise tax on sporting arms and ammunition. The funds are provided to the state on a matching basis for land acquisition, research, development, and management projects.

Similar appropriations were provided for in 1950 by the Federal Aid in Fish Restoration Act, also known as the Dingell-Johnson Act. Funds for aid to the states come from an excise tax on certain items of sport fishing tackle and are to be used for land acquisition, research, development, and management.

The beginning of the Commission system and the available federal assistance paved the way for the scientific, biologically sound management practices applied today.

The Arizona Game and Fish Department is responsible for the management of all game and nongame species of wildlife on lands within the state, except for migratory birds whose welfare is a Federal-State responsibility. Presently, wildlife species on Indian lands are not managed by the state. The Game and Fish Department and the Indian tribes recognize that a controversy exists concerning the ownership and management of fish and wildlife on the reservations.

Funds for the operation of the Arizona Game and Fish Department come from revenue derived from the sale of hunting and fishing licenses.

Land and water managing areas within the study area which are managed solely by the Arizona Game and Fish Department, or jointly with a federal agency, are Pena Blanca Lake and Waterfowl Management Area, Rose Canyon Lake, Rucker Canyon Lake, May Memorial Refuge, Manhattan Claims Wildlife Management Area, and Willcox Playa.

STATE, COUNTY, CITY, AND PRIVATE DEVELOPMENTS

Arizona Water Commission

This state agency participates in planning and investigation regarding the State's water resource use and development. It provides assistance involving (1) studies for flood plain zoning, (2) cost sharing for lands, easements, rights-of-way, and relocations associated with installation of federal flood control projects, (3) planning projects such as the Central Arizona Project and flood control projects of the Soil Conservation Service, (4) river basin studies, (5) cooperation with U.S. Geological Survey in collecting and analyzing data relating to the hydrology of surface water and ground water, (6) supervision of safety of dams, and (7) checking the adequacy of water supplies for large subdivisions prior to recordation of the plats.

Arizona State Land Department

This department, which administers 32 percent of the land within the study area, is responsible for more acreage than any other entity. The department is divided into several offices and divisions to allow orderly and efficient performance of its duties. The functions of these offices or divisions include:

1. Appraising, leasing, disposing, acquiring, and adjudicating land.

2. Administering water rights.

3. Inventorying resource.

4. Land use planning protection.

5. Managing resources such as soils, water, minerals, and energy, range and habitat, forest, and environment.

The Office of Natural Resource Conservation within the State Land Department has to date assisted and supervised the organization of the twelve Natural Resource Conservation Districts existing in the study area. It has developed for the Districts a number of official working arrangements and memoranda of understanding between districts and state and federal agencies engaged in programs of natural resource conservation and development. Much of the overall coordination and arrangements for cooperation achieved in state-wide conservation programs is furnished by this office. Agencies principally involved at this time are:

Federal Agencies:

Department of Defense:	Corps of Engineers, Air Force, Army Ordinance
Department of Agriculture:	Soil Conservation Service, Agricultural Stabilization & Conservation Service, Forest Service, Farmers Home Administration, Agricultural Extension Service, Agricultural Research Service.
Department of the Interior:	Bureau of Land Management, Bureau of Indian Affairs, Bureau of Reclamation, Fish and Wildlife Service, Geological Survey.
State Agencies:	Game & Fish Department, University of Arizona, Agricultural Experiment Station, Extension Service, Arizona State University, Northern Arizona University, Office of Economic Planning & Development, Arizona Water Commission, State Department of Education.

As the preceding illustrates, there is a great deal of coordination and cooperation between federal, state, and local agencies and governing bodies in their administration of land and water resource projects and programs. Federal agencies charged with administering specific programs usually have counterparts at the state or local level which assist them.

City, County, and Private Developments

Governing bodies of cities and counties have played a major role in the development and operation of land resource projects and programs. These local governing bodies' sponsorship is one of the main factors which determine projects' and programs' successes. Their solicitation of assistance has varied from (1) obtaining loans to improve municipal water and sewage treatment systems for existing developments to (2) obtaining basic data on soils, water supply, and flood hazards to regulate new developments. The type of data mentioned in the last category will be in greater demand as the trend in land-use planning and zoning continues.

Private enterprise has also contributed significantly in conserving and developing land and water resources. This has ranged from (1) obtaining financial and technical assistance in applying conservation practices on agricultural land to (2) using research data in developing new techniques of producing ore and water.

In order to preserve some measure of aesthetic qualities and lessen the impact of large-scale surface disturbances associated with open-pit mining activities south of Tucson, the mining companies are applying several types of land treatments. Revegetation of mine tailings with native grasses, trees, and shrubs is being conducted with considerable success. Some companies design their mine tailings to resemble the natural irregularity of the surrounding hills. On some tailings, level contoured benches are installed with sufficient widths for the possible future construction of houses and roads. This is being done on state lands within the mining area.

All known programs and projects are discussed elsewhere in this chapter. Therefore, no further discussion of individual state or local agencies is included here.

OTHER PROJECTS AND PROGRAMS

Bureau of Indian Affairs (BIA)

Since 13.9 percent of the Santa Cruz-San Pedro River Basins is Indian Trust land, the Bureau of Indian Affairs, U.S. Department of the Interior, plays a significant part in managing the resources of the study area. The BIA acts as a trustee for Indian lands and monies and assists the owners in making the most effective use of their resources. Another of its functions is the development and operation of all feasible irrigation projects on Indian lands. The authority to develop irrigation projects has taken different forms. Originally, various appropriation acts authorized construction of irrigation projects to deliver water to Tribal lands and to allotments made to Indians under the General Allotment Act of February 8, 1887, 24 Stat. 388. After 1910, no new irrigation projects on Indian reservations or allotments costing more than $35,000 could be undertaken without specific authority of Congress, 25, U.S.C., 383. The Secretary of the

Interior is also authorized to include Indian allotted lands in irrigation projects carried out under the Reclamation Act of June 17, 1902, 25 U.S.C. 382. The Congress has also provided for delivery of water to Indian lands from Reclamation projects authorized by specific Acts.

The policies under which the BIA operates with respect to Indian land and water resources include the retention of ownership by Indians and resource management for sustained-yield benefits. Resource use and conservation use programs involve agricultural development, forestry, grazing, irrigation, soil conservation, and industrial and tourism development on Indian lands. Present activities in the study area include all phases of conservation and management except forestry.

Bureau of Land Management (BLM)

This bureau is also an agency of the U.S. Department of the Interior. It has exclusive jurisdiction of 6.8 percent of the study area's acreage. The resource protection, management, and development activities of the BLM are conducted under a multiple use philosophy which attemps to miximize the total public and private benefits obtainable from the available financial and land resources.

The BLM carries out a coordinated program for the conservation and development of watersheds in order to preserve and protect the soil and water resources. The program is a combination of land treatment and structural practices having a planned pattern in support of multiple use management. It is designed to regulate surface water runoff, to control accelerated erosion, and to stabilize the soil resources. Fire protection and trespass control are other parts of this overall resource protection program.

Through the granting of grazing licenses, permits, and leases, the BLM administers grazing activity to protect the productivity of the lands and to permit the highest use of forage. The BLM also carries out programs for the rehabilitation of deteriorated rangelends and for sustained-yield forest management on timber lands under its jurisdiction to obtain continuous production at the highest possible level.

The BLM administers a program of development, conservation, and use of mineral resources through mineral leasing on federally owned public lands and on lands in other ownership on which the mineral rights are federally owned. This program applies to those minerals which are not open to patent under the mining law.

The Bureau has varied program responsibilities for management and development of outdoor recreation and wildlife values of the public domain lands. These activities inherently involve water protection and development. Included are the construction, operation, and maintenance of recreational facilities, participation with federal, state, and local agencies in cooperative programs involving the management of recreation and wildlife resources, and development of habitat for fish and wildlife.

Perpetuation of Aravaipa Canyon with its sheer cliffs, rock formations, permanent streamflow, plant communities, and bird, animal, and aquatic life, is a good example of how the BLM is working with a private entity. Both the Bureau of Land Management and Defenders of Wildlife attempt to preserve the beauty of the Aravaipa Canyon by controlling numbers of people entering the canyon and their length of stay. Rules are in effect requiring the disposal of decomposable waste and the packing out of waste with resistance to decay.

Bureau of Mines

As a research agency, the Bureau of Mines of the Department of the Interior is concerned with water supplies necessary to the production of the nation's minerals. It also is concerned with technology to reduce pollutants in both mining and milling process waters so that they may be recycled for further use. Research efforts of the Bureau of Mines are directed to these and related problems as permitted by the priorities of its overall program.

Fish and Wildlife Service

This agency of the Department of the Interior has many varied activities in the basin. These include:

1. Carrying out agreements with Mexico to protect migratory birds.

2. Researching of fish and wildlife.

3. Making surveys, developing plans, and assisting other agencies in making plans to prevent losses and to enhance fish and wildlife.

4. Providing states with funds for fish and wildlife restoration work.

5. Assisting in conservation, restoration, and propagation of endangered species.

The Fish and Wildlife Service has a project which deals specifically with item 5. The project's purpose is to re-establish populations of masked bobwhite quail in the grasslands of the study area.

Bureau of Outdoor Recreation (BOR)

The BOR is responsible for preparing and maintaining a continuing inventory and evaluation of the outdoor recreation resources; formulating and maintaining a comprehensive nation-wide outdoor recreation plan; promoting coordination of federal plans and activities relating to outdoor recreation; cooperating with and providing technical assistance to states, political subdivisions, and private interests; encouraging interstate and regional cooperation; sponsoring, engaging

in, and assisting with research relating to outdoor recreation; and cooperating with and providing technical assistance to federal departments and agencies.

Under the Land and Water Conservation Fund Act of 1965, the BOR also administers a program of financial assistance grants to states for the purpose of facilitating outdoor recreational planning, acquisition, and development activities. Under the provisions of the Federal Water Project Recreation Act, the BOR participates directly in the planning, coordination, and establishment of uniform policies with respect to recreation and fish and wildlife benefits and costs of federal multi-purpose water resource projects.

Environmental Protection Agency (EPA)

Established in December 1970, the EPA brought together in one federal agency many environmental protection programs previously carried out by several different branches of government. EPA's responsibilities encompass a range of environmental concerns--air pollution, water pollution, solid waste management, pesticides, noise, and radiation.

EPA has responsibility for establishing environmental standards, monitoring and enforcing standards, conducting research and development, and providing financial, training, and technical assistance for the purpose of protecting or improving the quality of the environment.

The Nation's air pollution control program is carried out under the Clean Air Act of 1970. The Act created a nationwide program to control air pollution through setting and enforcing standards.

The Nation's program to prevent, reduce, and eliminate water pollution is carried out under the Water Pollution Control Act of 1972. This Act extended the National program to all navigable water bodies of the United States.

The National Environmental Protection Act of 1969, (NEPA) is administered by the EPA. The Act recognizes the impact of man's activities on the environment and established national policies and goals for maintaining the environmental quality. National policy requires the use of financial and technical assistance to maintain productive harmony between man and his natural surroundings. Government agencies are directed to (1) use a systematic, interdisciplinary approach that integrates social and natural sciences and environmental design arts in planning and decision making that may have an impact on man's environment; identify and develop methods and procedures is consultation with the Council on Environmental Quality; (3) include in every recommendation or report on proposals the environmental impact of the proposed action, any adverse environmental effects that cannot be avoided should the proposal be implemented, alternatives to the proposed action, relationship between local short-term uses and long-term productivity, and any irreversible and irretrievable committments of resources; (4) study, develop, and describe appropriate alternatives to recommended courses of action in any proposal that involves unresolved conflicts

concerning alternative uses of available resources; and (5) initiate and utilize ecological information in the planning and development of resource oriented projects.

Geological Survey (GS)

This Department of the Interior agency determines the source, quantity, quality, distribution, movement, and availability of both surface and ground waters. This work includes investigations of floods and droughts, their magnitude, frequency, and relation to climatic and physiographic factors; the evaluation of available waters in river basins and ground water provinces, including water requirements for industrial, domestic, and agricultural purposes; the determination of the chemical and physical quality of water resources and the relation of water quality and suspended sediment load to various parts of the hydrologic cycle; special hydrologic studies of the interrelations between climate, topography, vegetation, soils, and the water supply; research to improve the scientific basis of investigations and techniques; scientific and technical assistance in hydrologic fields to other federal agencies; and the coordination of national network and special water data acquisition activities of federal agencies.

The Geological Survey also makes geologic surveys and investigations to determine and appraise the mineral-fuels resources and the geologic structure of the United States and its territories. These investigations define the subsurface geology and character of waterbearing rocks, and assist in defining the magnitude and movement of ground water resources.

The results of these investigations are published in the series of Geological Survey publications and in publications of various state agencies cooperating in the work. Publications of the Geological Survey include water supply papers, bulletins, professional papers, circulars, and maps, many of which are applicable to the Santa Cruz-San Pedro River Basins. The papers cover inventories, drainage problems and a myriad of specific data relevant and necessary to a comprehensive understanding of water and mineral resource development

National Park Service (NPS)

This agency of the Department of the Interior administers 0.9 percent of the land in the study area. The programs carried on by the National Park Service stem primarily from its responsibility to provide and promote the use of areas for public enjoyment and to protect the natural and historic resources comprising such areas. These activities include development of water supplies, sewage treatment facilities, and water-based recreation facilities. The protection program consists not only of preventing fires, stream pollution, and injury to natural, historic, or prehistoric features, but also of restricting uses that are incompatible with the basic purposes of the parks. An integral part of the overall program is to provide for the needs of the visiting public. The Service also conducts interpretive, informational, and investigative programs relating to park resources and use.

The National Park Service conducts and contracts for studies directed toward solving national park system resource and conservation problems. Studies are made concerning pertinent aspects of water, as well as natural sciences, history, archeology, fish, wildlife, soil, and geology. The studies are used as a basis for more effective management, development, and conservation of the national park systems. Also, the NPS conducts continuing special studies in selective fields.

The National Park Service exercises the authority of the Secretary of the Interior under the Act of June 27, 1960, (popularly termed the River Basin Salvage Act) which specifically provides for the preservation of historical and archeological features that might be irreparably lost or destroyed as the result of activities associated with the construction of dams or through the impoundment of waters behind dams. Surveys of project areas are made to evaluate the historical and archeological resources. Investigations are undertaken to determine significance of threatened resources. Information contained in important sites and their associated micro-environments are scientifically studied; and the information they contain, including representative artifacts, are salvaged.

Under the authority of the Park, Parkway, and Recreation Area Act, the Park Service has been active in assisting the Bureau of Reclamation in planning, developing, and administering recreation at Reclamation reservoirs.

Federal Insurance Administration (FIA)

This agency of the Department of Housing and Urban Development is responsible for carrying out the provisions of the National Flood Insurance Program. Other federal agencies, such as the Army Corps of Engineers, Bureau of Reclamation, and Soil Conservation Service, with expertise in flood control prepare reports which describe and delineate flooding in flood hazard areas. The Federal Insurance Administration then uses reports to determine the areas where flood insurance is to be made available and to determine the insurance premium rates. These reports can also be utilized by local governing bodies to set building codes and land-use zoning.

International Boundary and Water Commission (IBWC)

The IBWC is a segment of the Department of State. In Arizona, the IBWC has responsibilities along the boundary between the United States and the Republic of Mexico. Following is a list of legislation administered by IBWC and current activities which pertain to the study area:

Douglas Sanitation Project - Public Law 786, 64 Stat. 846 (approved September 13, 1950) 22 USCA Sec. 277d-6. "An act to facilitate compliance with the Treaty between the United States of America and the United Mexican States signed February 3, 1944."

The project, consisting of primary and secondary treatment works, was constructed in 1947-1948 through the IBWC. In 1961, and again in

1966, the plant was improved and expanded through the IBWC to keep up with the needs of the growing cities. Since 1964, the physical works in both the United States and Mexico have been operated under the direct supervision of its section with overall control by the IBWC.

Nogales Flood Control Project - Act of August 19, 1935 - Exchange of notes between the Governments of the United States and Mexico on original project. Construction 1933 through 1936 performed with allotments from Public Works Administration funds; 1948-1949 construction authorized by Appropriation Act for F.Y. 1947, Public Law 490.

The constructed works consist of an international system of lined flood conduits beginning in Nogales, Sonora, and extending downstream northward across the international boundary and through Nogales, Arizona to provide flood protection to the two adjoining border cities. The United States portion of the project was completed in 1949 and turned over to the city of Nogales, Arizona for operation and maintenance under the technical supervision of the United States section of the IBWC.

Nogales Sanitation Project Public Law 150, 67 Stat. 195 (approved July 27, 1953) 22 USCA Sec. 277-d-10. "An act to authorize an agreement between the United States and Mexico for the joint operation and maintenance by the International Boundary and Water Commission, United States and Mexico, of the Nogales Sanitation Project, and for other purposes."

The existing international project for correction of the serious sanitation problem at the adjoining border cities of Nogales, Arizona and Nogales, Sonora had become badly overloaded.

New facilities have been installed to correct this problem. These facilities consist of an enlarged international outfall sewer about 8.8 miles in length and sewage treatment facilities consisting of aerated lagoons and stabilization ponds with capacity estimated to be adequate for both cities until the year 2000.

Construction of the enlarged international project, the cost of which was met by the United States, Mexico, and the city of Nogales, Arizona was completed in 1971. The facilities are operated and maintained by the city of Nogales, Arizona under the technical supervision of the IBWC. Costs of operation and maintenance are shared by Mexico and the city of Nogales, Arizona.

Department of Defense

The military manages the land under its jurisdiction mainly for defense purposes. However, some areas are not utilized as heavily as others and lend themselves to multiple uses such as recreation, wildlife, and grazing. The Department of Defense seeks and obtains technical assistance from other agencies with expertise in applicable areas when such uses are planned.

GLOSSARY

Acre-foot - The volume of liquid or solid required to cover an acre to a depth of one foot. 43,560 cubic feet = 325,850 gallons.

Alluvial basin - Structurally formed depression in the earth's surface filled with alluvium.

Alluvial fan - Low, cone-shaped sediment deposit built by a river or intermittent stream issuing from mountains upon lowlands.

Alluvium - A general term for all deposits of clay, silt, sand, gravel, cobbles, and/or boulders resulting from the operation of modern streams, including the sediments laid down in river beds, flood plains, lakes, and fans at the foot of mountain slopes.

Andesitic - Similar to or composed of andesite, a fine grained volcanic rock, generally of dark gray color.

Aquifer - A permeable geologic formation, group of formations, or part of a formation which stores and transmits water.

Artesian aquifer - An aquifer in which the water is under sufficient pressure to cause water to rise in a well above the top of the aquifer tapped by the well.

Average - The exact value obtained by dividing the sum total of a set of figures by the number of figures. (see mean)

Average annual runoff - That portion of the precipitation on a drainage area that is discharged from the area in stream channels on an average annual basis.

Bajada - The surface of a somewhat continuous apron sloping away from a mountain front. It is composed of merging alluvial fans.

Basin - An extensive depressed area into which the adjacent land drains.

Bedding plane - In sedimentary or stratified rocks, the division planes which separate the individual layers, beds, or strata.

Catchment - A watering facility consisting of a pit constructed to store water. A dam is not relied upon. The drainage area is very limited and could include only the area of the pit itself. Some catchments have small paved or otherwise treated areas to collect precipitation and convey it to the pit.

cfs - Cubic feet per second.

Chaparral - A brush community composed of evergreen, sclerophyllous species.

Charco - A water structure consisting of a desilting basin and a holding basin. The water runs into the desilting basin where the sediment drops out, and the water flows to the holding basin through a pipe. A dam is

not relied upon to hold water.

Claim - That portion of public mineral lands held under federal and local laws by one claimant or association.

Cone of depression - Depression, roughly conical in shape, produced in a water table or piezometric surface by the extraction of water from a well or wells.

Confined - A term applied to ground water indicating that the water is under pressure significantly greater than atmospheric and that its upper limit is the bottom of a bed of distinctly lower permeability than that of the material in which the confined water occurs.

Conglomerate - Rounded, waterworn fragments of rocks and pebbles, cemented together by another mineral substance.

Conservation capacity - Capacity in a reservoir or reservoirs used to store water for such purposes as municipal and industrial supply, agricultural water management, recreation, fish and wildlife, or water quality management as opposed to capacity for flood prevention or sediment.

Consumptive use - A use of water which reduces the amount of available water.

Cretaceous - The last of three periods included in the Mesozoic Era. The time spanned by the period extended from roughly 136 million years to 65 million years ago.

Depletion - The amount of water which is removed from supplies by a specified use. In this report only direct loss of water associated with the use is presented. Water loss from such things as lake evaporation and phreatophytes is not presented in the table of depletions.

Depletion requirement - The quantity of water consumptively required in vegetative growth, food processing, industrial processes, or in other ways which remove water from availability.

Detritus - Fragmental materials such as gravel, sand, silt, and clay derived from disintegration of older rocks.

Differential erosion - The more rapid erosion of one portion of the earth's surface as compared with another.

Diffused surface water - A term associated with Arizona water law which refers to surface waters that are not in a clearly defined channel. Diffused surface waters are not subject to appropriation.

Dissected - Cut by erosion into hills and valleys.

Dugout - A depression either natural or artificial, that impounds water. A dam is not relied upon to back up water.

Dolomite - A sedimentary rock composed essentially of calcium magnesium carbonate.

Double cropping - Two or more crops grown to maturity on the same portion of land within one year.

Drought - A prolonged period during which precipitation is less than the normal for the area.

Endangered species - Fish and wildlife species which are in danger of extinction throughout all or a significant portion of its range.

Ephemeral stream - A stream or portion of a stream which flows only in direct response to precipitation. It receives little or no water from springs and no long continued supply from snow or other sources. Its channel is at all times above the water table.

Erosion - The detachment of soil and rock particles by water, wind, ice, or gravity.

Erosion pavement - A surface covering of stone, gravel, or coarse soil particles accumulated as the residue left after sheet, rill, and/or wind erosion have removed the finer soil.

Evapotranspiration - A term embracing that portion of the precipitation returned to the air through direct evaporation or by transpiration of vegetation, no attempt being made to distinguish between the two.

Facies - General appearance or nature of one part of a rock body as contrasted with other parts. May differ in composition, appearance, texture, etc.

Fault - A fracture or fracture zone in rock along which there has been displacement of the sides relative to one another parallel to the fracture. The displacement may be a few inches or many miles.

Fault block - A body of rock bounded by one or more faults.

Fishery - Any water permanently sustaining fish life.

Float deposit - Ore or rock which has fallen from or has been separated from the parent vein or strata by weathering agencies.

Flood plain - Land bordering a watercourse which receives overbank flow. In Arizona water law, any land where substantial flood damage may occur may be subject to flood plain regulations.

Fluvial - Of or pertaining to rivers; growing or living in streams or ponds; produced by river action, as a fluvial plain.

Fold - A bend or flexure in a layer or layers of rock.

gpm - Gallons per minute.

Granitic intrusion - The process of granite or granite-like rock invading older rock as magma or hot plastic solid. The granitic rock consolidated from magma beneath the earth surface.

Gross annual evaporation - Average annual evaporation of water from reservoirs, streams, and the soil. Does not include transpiration.

Ground water model - The basic procedure in modeling a ground water basin is to divide the model acres into ground water nodes. A ground water node is an area of reference or an area of investigation. Each node may be viewed as a small underground reservoir which has flow entering and leaving its boundaries through various means--entering through natural recharge, irrigation return flow seepage, internal boundary flow, etc., leaving through pumpage, evaporation, crop consumption use, phreatophyte use, and internal boundary flow. The change in storage is also evaluated.

First a verification model is developed by arriving at inflow and outflow estimates for each of the above factors for each ground water node. This evaluation is made for a reference period of time (at least five years). Water level countour maps are necessary for the beginning and ending years of the period selected. Average water level elevations are then calculated for each ground water node for each of the reference years. The accuracy of the verification model is checked by comparing the change in elevation calculated by the model to the change indicated by the water level contour maps. Once the model has been verified with sufficient accuracy, it can be used for evaulating the effect of future demands on the ground water system.

Gymkhana - An arena used for equestrian events.

Hydraulic gradient - Pressure gradient. As applied to an aquifer, it is the rate of change of pressure head per unit of distance of flow at a given point and in a given direction.

Igneous - Applied to rocks formed by solidification from a molten state.

Igneous intrusion - The process of hot mobile material (magma) invading older rock and solidifying beneath the surface of the earth. The rock mass so formed.

Infiltration - The process whereby water passes through an interface, such as from air into soil.

Infiltration rate - Rate at which soil can absorb water.

Intermittent stream - A term which applies to stream reaches which flow during wet weather or during a part of the year.

Jurassic - The middle of three periods included in the Mesozoic Era. The time spanned by the period extended from roughly 190 million years to 136 million years ago.

Laramide Orogeny - Large scale deformation of the earth's crust during late Cretaceous and early Tertiary time.

Lithology - As used in this report, the term refers to the composition and texture of rock.

Mean - Average.

Median - A value in an ordered set of values below and above which there are an equal number of values.

Metamorphic - Pertaining to rocks which have changed in texture, structure or composition in response to pronounced changes of temperature, pressure and chemical environment.

Miocene - The fourth of the five epochs into which the Tertiary Period is divided. The time spanned by the epoch extended from roughly 26 million years to 12 million years ago.

Normal - Average.

OBERS Projections - Projections of population, employment earnings, value of output, and broad land-use categories. These projections were developed by the former Office of Business Economics and the Economic Research Service.

Orographic precipitation - Precipitation which results from the lifting of moist air over a topographic barrier such as a mountain range.

Outcrop - That part of a body of rock which appears at the surface or is overlain only by soil or thin alluvium.

Overdraft - Groundwater pumping in excess of ground water recharge.

Paleozoic - One of the eras of geologic time occurring between the late Precambrian and Mesozoic eras. It comprises the Cambrian, Ordovician, Silurian, Devonian, Mississippian, Pennsylvanian, and Permian periods. The time spanned by the era extended from roughly 570 million years to 225 million years ago.

Percolate - To pass through fine voids; to filter, as water percolates through porous stones.

Permeability - The capacity for transmitting a fluid.

Perennial stream - A stream or portion of a stream that flows throughout the year.

Peripheral species or subspecies - Fish and wildlife species or subspecies whose occurrence in the United States is at the edge of its natural range and which is threatened with extinction in the United States although not in its range as a whole.

Phreatophyte - A plant that habitually obtains its water supply from the zone of saturation.

Physiographic province - A region of similar geologic structure and climate that has a unified geomorphic history.

Piping - Removal of soil material through subsurface flow channels or "pipes" developed by percolating water.

Placer deposit - A mass of gravel or sand resulting from erosion of solid rocks and containing particles or nuggets of valuable minerals.

Pleistocene - The earlier of two epochs which comprise the Quaternary Period. Also called the Glacial Epoch and formerly called Ice Age. The time spanned by the epoch extended from roughly two million years to ten thousand years ago.

Pliocene - The last of the five epochs into which the Tertiary Period is divided. The time spanned by the epoch extended from roughly twelve million years to two million years ago.

Porosity - The measure of void space in a volume of material.

Porphyry - Hard igneous rock in which are contained large, conspicuous crystals (phenocrysts) in fine grained ground mass.

Precambrian - The earliest era of geologic history, ending approximately 570 million years ago.

Pyroclastic - Composed of fragments of volcanic materials that have been explosively or aerially ejected from a volcanic vent. Agglomerate and tuff are pyroclastic rocks.

Quartz monzonite - An intrusive igneous rock of granitic appearance.

Quaternary - The youngest of geologic periods. It is divided into Pleistocene and Holocene (Recent) epochs. Beginning roughly two million years ago, it extends to present time.

Ranchette - Homesites of one to ten acres.

Recharge - Inflow to a ground water reservoir.

Relative humidity - The ratio of the actual amount of water vapor in a given volume of air to the amount which would be present were the air saturated at the same temperature, expressed as a percentage.

Relief - The difference in elevation between high and low points of a land surface.

Rhyolitic - Similar to or composed of rhyolite (a lava generally of light color; the extrusive equivalent of granite).

Riparian - Relating to or located or living along a watercourse whether natural, man-made, ephemeral, intermittent, or perennial.

Salvage logging - A type of operation which removes scattered, dead, down, and poor risk trees that will not be merchantable if left in the stand until the next scheduled cut.

Sediment - The solid material that has been detached from its place of origin by erosion and is either in suspension, is being transported, or has been deposited.

Sedimentary - Pertaining to rocks formed of sediment which accumulated in water or from air. The sediment may consist of rock fragments or particles, the remains of animals and plants, or the product of chemical action or of evaporation.

Specific capacity - The water yield of a well per unit of drawdown, usually expressed as gallons per minute per foot of drawdown.

Specific yield - The amount of water a saturated material will yield to gravity drainage expressed as a ratio of the volume of water to the volume of material.

Sonoran Geosyncline - A large portion of the earth's crust in northern Sonora, Mexico, southwestern New Mexico and southeastern Arizona which was subjected to downward warping during the Paleozoic and Mesozoic eras while sedimentary and volcanic rocks accumulated.

Status undetermined species - Fish and wildlife species or subspecies which have been suggested as possibly threatened with extinction but sufficient information to determine its status is not available.

Stock tank - A structure for impounding water, formed by an excavation and an earthen dam across a drainage or by excavation of a pit.

Storage coefficient - The volume of water released from or taken into storage per unit surface area of the aquifer per unit change in head. In an unconfined aquifer, storage coefficient is approximately equal to specific yield.

Stratigraphic - Relating to the arrangement, distribution and succession of geologic strata.

Structural depression - A depression formed as a consequence of geologic structure.

Subsidence - A sinking of a part of the earth's crust.

Tertiary - The earlier of two periods into which the Cenozoic Era is divided. The Tertiary Period includes the Paleocene, Eocene, Oligocene, Miocene and Pliocene epochs. The time spanned by the period extends from roughly 65 million years to 2 million years ago.

Threatened species - A fish or wildlife species or subspecies which are likely to become endangered within the foreseeable future throughout all or a significant portion of its range.

Transpiration - The process by which water escapes from a living plant and enters the atmosphere.

Triassic - The earliest of three periods into which the Mesozoic Era is divided. The time spanned by the period extended from roughly 225 million years to 190 million years ago.

Unconfined - A term applied to ground water in an aquifer that has a water table.

Unit runoff - In this report, this term is defined as average annual yield, in inches of water, over the entire drainage area. The valve is determined by dividing the runoff at a point on a stream by the drainage area above that point.

Unconformable - Pertaining to geologic strata having the relation of unconformity to the strata lying immediately beneath; not succeeding the underlying strata in immediate order of age and in parallel position.

Unconformity - A surface of erosion or nondeposition which separates younger strata from older rocks.

Uplift - Elevation of a part of the earth's crust.

Valley alluvium (valley fill) - Usually very thick valley deposits of unconsolidated and semi-consolidated sediment derived from erosion of bordering mountains.

Watershed - The area contained within a drainage divide above a specified point on a stream.

Water table - The level below which all pores, cracks, and crevices are filled with water.

Withdrawal - In this report, this term is defined as water which is physically diverted from a surface water source or pumped from the ground water.

Withdrawal requirement - The total quantity of water required under present or projected efficiencies to satisfy the depletion requirement.

REFERENCES

(1) Federal Register, 1973. Water and Related Land Resources, Establishment of Principals and Standards for Planning. Water Resources Council. Vol. 38, No. 174, Part III.

(2) USDA, 1974. USDA Procedures for Planning Water and Related Land Resources in Programs Administered by the Soil Conservation Service. Economic Research Service, Forest Service, Soil Conservation Service.

(3) Green, G.R., and W.D. Sellars, 1964. Arizona Climate. University of Arizona Press.

(4) Wilson, Eldred D., 1962. A Resume of the Geology of Arizona. Arizona Bureau of Mines, Bulletin 171.

(5) USDI, 1969. Mineral and Water Resources of Arizona, for use by Committee on Interior and Insular Affairs, 90th Congress, 2nd Session. Also published as Arizona Bureau of Mines Bulletin 180.

(6) USDA, 1955. From Ocean to Sky to Land to Ocean. Yearbook of Agriculture.

(7) USDI, 1970. Streamflow in the Upper Santa Cruz River Basin, Santa Cruz and Pinal Counties, Arizona. Geological Survey, Water Supply Paper 1939-A.

(8) Smith, G.E.P., 1910. Ground Water Supply and Irrigation in the Rillito Valley, Arizona. University of Arizona, Agricultural Experiment Station Bulletin 64.

(9) Hastings, J.R., 1958. Vegetation Changes and Arroyo Cutting in Southeastern Arizona During the Past Century - A Historical Review. University of Arizona, Desert Lands Colloquia.

(10) Burkham, D.E., 1970. Depletion of Streamflow by Infiltration in the Main Channels of the Tucson Basin, Arizona. USDI, Geological Survey Water-Supply Paper 1939-B.

(11) Roeske, R.H. and W. L. Werrell, 1971. Hydrologic Conditions in the San Pedro River Valley, Arizona. USDI, Geological Survey. Arizona Water Commission Bulletin 4.

(12) Lohman, S.W. and Others, 1972. Definitions of Selected Ground Water Terms - Revision of Conceptual Refinements. USDI, Geological Survey, Water-Supply Paper 1988.

(13) Arizona Water Commission, in preparation. Study of the Adequacy of Water Supply, Proposed Empire Ranch Development.

(14) Andersen, T.A., 1970. Electrical-Analog Analysis of the Hydrologic System, Tucson Basin, Arizona. USDI, Geological Survey Water-Supply Paper 1939-C.

(15) Davidson, E.S., 1970. Geohydrology and Water Resources of the Tucson Basin, Arizona. USDI, Geological Survey, Open-File Report.

(16) Ostercamp, W.R., 1973. Map Showing Distribution of Recoverable Ground Water in the Tucson Area, Arizona. USDI, Geological Survey.

(17) Ostercamp, W.R., 1973. Map Showing Distribution of Recoverable Ground Water in the Phoenix Area, Arizona. USDI, Geological Survey.

(18) Brown, S.G., and H. H. Schumann, 1969. Geohydrology and Water Utilization in the Willcox Basin, Graham and Cochise Counties, Arizona. USDI, Geological Survey Water-Supply Paper 1859-F.

(19) USDI, 1972. Hydrologic Conditions in the Douglas Basin, Cochise County, Arizona. Geological Survey, Water Resources Report No. 30.

(20) Dutt, G.R., and T. W. McCreary, 1970. The Quality of Arizona's Domestic, Agricultural, and Industrial Waters. University of Arizona, Report No. 256.

(21) Heindl, L.A., and O. J. Cosner, 1961. Hydrologic Data and Drillers' Logs, Papago Indian Reservation, Arizona. USDI, Geological Survey Water Resources Report No. 9 for Arizona Water Commission.

(22) City of Tucson, Arizona, 1961. Northwest Area Well Field Development Report for City of Tucson. Department of Water and Sewers, Planning and Research Section.

(23) Richards, L.A., and Staff of U.S. Salinity Laboratory, 1954. Diagnosis and Improvement of Saline and Alkali Soils. USDA Handbook No. 60.

(24) USDI. Water Resource Data for Arizona, Part 2, Water Quality Records. Geological Survey. Prepared in cooperation with the State of Arizona and other agencies.

(25) Benson, Lyman, and Robert D. Darrow, 1944. A Manual of Southwestern Desert Trees and Shrubs. Biological Science, Bulletin 6, University of Arizona, Tucson, Arizona.

(26) Humphrey, Robert R., 1958. The Desert Grassland, A History of Vegetational Change and an Analysis of Causes. Bulletin 299, Agricultural Experiment Station, University of Arizona, Tucson, Arizona.

(27) Humphrey, Robert R., 1960. Forage Production on Arizona Ranges, Vol. V. Pima, Pinal, and Santa Cruz Counties. Bulletin 302, Agricultural Experiment Station, University of Arizona, Tucson, Arizona.

(28) Nichol, A.A., 1952. The Natural Vegetation of Arizona. Technical Bulletin 68, Arizona Experiment Station, University of Arizona, pp. 188-230.

(29) Shreve, Forest, 1942. The Desert Vegetation of North America. Botanical Review VIII, pp. 195-246.

(30) Shreve, Forest, 1951. Vegetation of the Sonoran Desert. Carnegie Institute, Washington, Publication 591.

(31) Ames, Charles, R., 1969. A History of the International Boundary Survey. (Typewritten Report)

(32) Horton, Jerome, S., 1973. Evapotranspiration and Water Research as Related to Riparian and Phreatophyte Management. USDA, Forest Service, Miscellaneous Publication 1234, 192 pp.

(33) Bowie, James E., and William Kam, 1968. Use of Water by Riparian Vegetation, Cottonwood Wash, Arizona. United States Government Printing Office, 62 pp.

(34) Leopold, Aldo, 1924. Grass, Brush, Timber, and Fire in Southern Arizona. Journal of Forestry, Vol. 22 (b): pp. 1-10.

(35) Cable, Dwight R., 1972. Fire Effects in Southwestern Semi-Desert Grass-Shrub Communities. Proceedings Tall Timbers Fire Ecology Conference, illustrated, pp. 109-127.

(36) USDI, 1974. Threatened Wildlife of the United States. U.S. Fish and Wildlife Service, Resource Publication No. 114.

(37) USDI, 1972. National Registry of Natural Landmarks.

(38) Bivens and Associates, Inc., 1972. Statewide Comprehensive Outdoor Recreation Plan. Arizona Outdoor Recreation Coordinating Commission, Phoenix, Arizona.

(39) Federal Register, February 1975. Arizona Recreation Plan, 1972. Vol. 40, No. 24.

(40) Granger, Byrd, H., 1973. Arizona Place Names. University of Arizona Press, Tucson.

(41) Arizona State Department of Health, 1972. The State of Arizona Air Pollution Control Implementation Plan. (Revision No. 1)

(42) Arizona Department of Health Services, 1974. 1973 Air Quality Data for Arizona.

(43) Arizona Crop and Livestock Reporting Service, 1972. Arizona Agriculture Statistics Bulletin S-7.

(44) Lower Colorado Region Comprehensive Framework Study, 1971. Appendix XIV, Electric Power.

(45) Beaty, Chester B., 1968. Sequential Study of Desert Flooding in the White Mountains of California and Nevada. Technical Report 68-31-ES.

(46) Lewis, Douglas D., 1962. Desert Floods, A Report on Southern Arizona Floods of September 1962. U.S. Geological Survey. Also Published as Water Resources Report Number 13, Arizona State Land Department.

(47) Hastings, James Rodney, and Raymond M. Turner, 1965. The Changing Mile, An Ecological Study of Vegetation Change with Time in the Lower Mile of an Arid and Semi-Arid Region. University of Arizona Press, Tucson, Arizona, 317 pp.

(48) USDI, 1963. Water Requirements and Uses in Arizona Mineral Industry. Bureau of Mines, Information Circular 8162. Figure 7.

(49) Fuhriman, Dean K. and James R. Barton, 1971. Ground Water Pollution in Arizona, California, Nevada, and Utah. Environmental Protection Agency.

(50) Davis, Gordon E., and John F. Stafford, 1966. First Annual Report, Tucson Wastewater Reclamation Project. City of Tucson, Water and Sewers Department.

(51) Lower Colorado Region Comprehensive Framework Study, 1971. Appendix XV, Water Quality, Pollution Control, and Health Factors. Water Resources Council.

(52) State of Arizona, 1975. Arizona Remote Subdivisions, An Inventory. Office of Economic Planning and Development.

MAPS

SANTA CRUZ - SAN PEDRO RIVER BASINS
ARIZONA

SEPTEMBER 1977

LEGEND

deposits	Ks	Cretaceous sedimentary and volcanic rocks
ks	Kv	
edimentary	Ka	
olcanic	Kvs	
ikes and	Kls	Lower Cretaceous sedimentary roc
	Mzgr	Mesozoic granite to quartz diorite
ks	Mzv	Mesozoic volcanic rocks
	JTrg	Triassic - Jurassic intrusive rock
	PIPn	Pennsylvanian-Permian sedimentary rocks (Naco Group undivided)
	Pnu	Upper formations of Naco Group
plugs	PIPnl	Lower formations of Naco Grou
osits	Pzs	Paleozoic sedimentary rocks undivided
edimentary	MDs	Devonian and Mississippian sedimentary rocks
	O€s	Cambrian and Ordovician sedimentary rocks
olcanic	p€a	Younger Precambrian sedimentary and volcanic rocks
	p€db	Younger Precambrian diabase
trusive	p€t	Younger Precambrian quartzite
	p€gr	Older Precambrian intrusive rocks
etamorphic	p€sc	Older Precambrian metamorphosed sedimentary and volcanic rocks
entary rocks	p€gn	

ETAILED LEGEND ON REVERSE

ic Map of Arizona by Eldred D. Wilson
hard T. Moore, Arizona Bureau of Mines
n R. Cooper, U.S. Geological Survey.

GEOLOGY
SAN PEDRO RIVER BASINS
ARIZONA

JULY 1974

0 10 20 MILES
SCALE 1:1,000,000

Source:
Base map prepared by SCS, WTSC Carto Unit from USGS 1:500,000 series.
Thematic detail compiled by state staff.
U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE USDA-SCS-PORTLAND OR 1977

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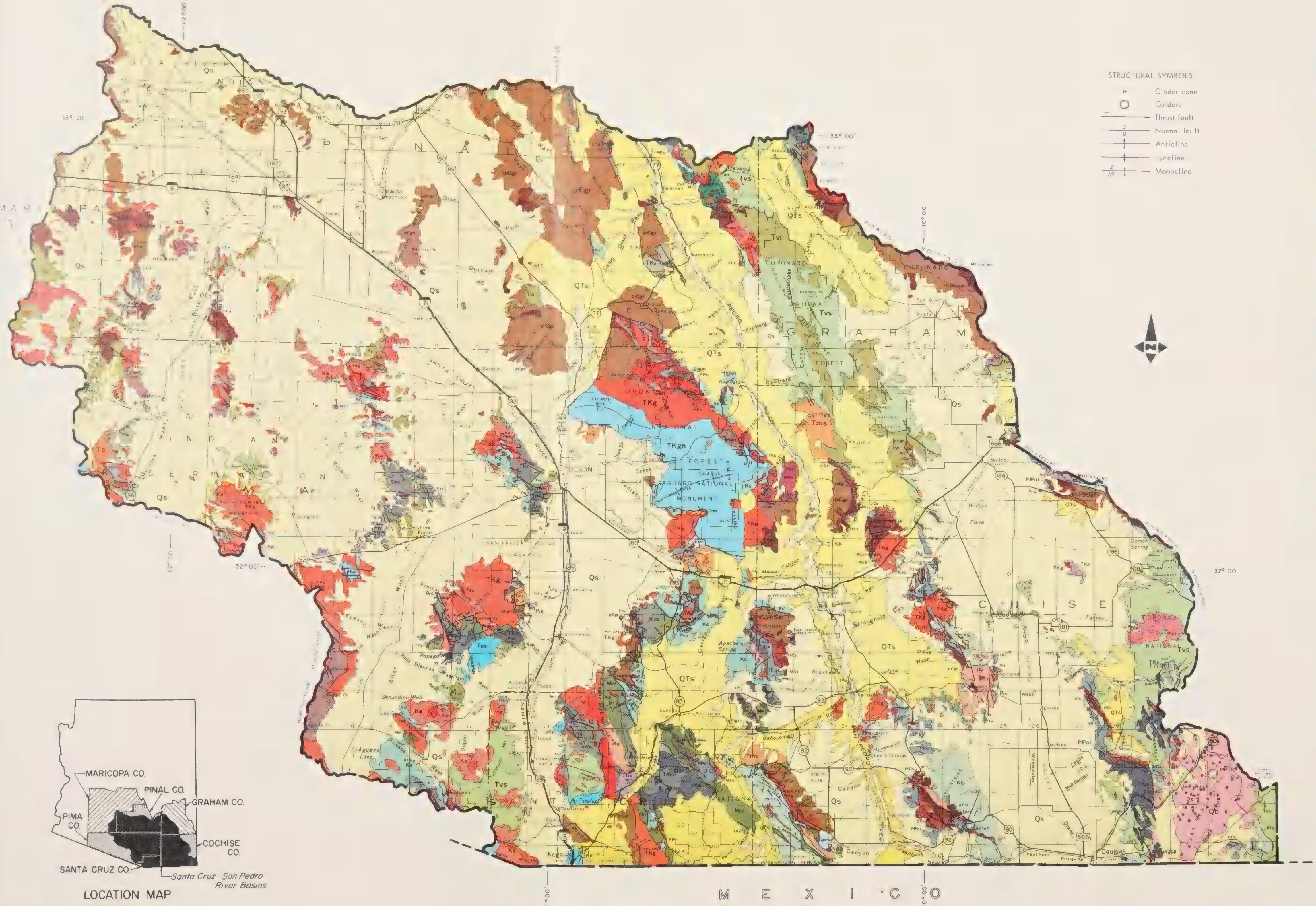
M7-EN-23185-3



LEGEND

Qs	Quaternary sedimentary deposits
Qb	Quaternary volcanic rocks
QTs	Tertiary - Quaternary sedimentary rocks
QTb	Tertiary - Quaternary volcanic rocks
QTi	Tertiary - Quaternary dikes and plugs
Tms, Ts	Tertiary sedimentary rocks
Tv, Tvs, Tvi	Tertiary volcanic rocks
Ti	Tertiary dikes, sills and plugs
Tps	Tertiary sedimentary deposits
TKs	Cretaceous - Tertiary sedimentary rocks
TKv, TKa, TKr	Cretaceous - Tertiary volcanic rocks
TKg, TKi	Cretaceous - Tertiary intrusive rocks
TKsc, TKgn	Cretaceous - Tertiary metamorphic rocks
Kus	Upper Cretaceous sedimentary rocks
Ks, Kv, Ka, Kvs	Cretaceous sedimentary and volcanic rocks
Kls	Lower Cretaceous sedimentary rocks
Mzgr	Mesozoic granite to quartz diorite
Mzv	Mesozoic volcanic rocks
JŦg	Triassic - Jurassic intrusive rocks
PIPn	Pennsylvanian-Permian sedimentary rocks (Naco Group undivided)
Pnu	Upper formations of Naco Group
PIPnl	Lower formations of Naco Group
Pzs	Paleozoic sedimentary rocks undivided
MDs	Devonian and Mississippian sedimentary rocks
O€s	Cambrian and Ordovician sedimentary rocks
p€a	Younger Precambrian sedimentary and volcanic rocks
p€db	Younger Precambrian diabase
p€t	Younger Precambrian quartzite
p€gr	Older Precambrian intrusive rocks
p€sc, p€gn	Older Precambrian metamorphosed sedimentary and volcanic rocks

SEE DETAILED LEGEND ON REVERSE

Source:
Geologic Map of Arizona by Eldred D. Wilson and Richard T. Moore, Arizona Bureau of Mines and John R. Cooper, U.S. Geological Survey, 1969

GEOLOGY
SANTA CRUZ - SAN PEDRO RIVER BASINS
ARIZONA

JULY 1974

10 0 10 20 MILES
SCALE 1:1,000,000

U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE

M7-EN-23185-3

LEGEND

QUATERNARY — Pleistocene & Recent

Qs SEDIMENTARY DEPOSITS
Mainly alluvial gravel, sand, and silt in flood plains, terraces, fans, and pediment cappings but locally includes dune sand, lake deposits, and landslide masses. Shown only in areas where they are of appreciable thickness or extent

Qb VOLCANIC ROCKS
Basaltic flows, agglomerate, tuffs, and cinders distinguished from older basalts by recognizable cinder cones, calderas, and other geomorphic evidence of youth

TERTIARY & QUATERNARY — Pliocene & Pleistocene

QTs SEDIMENTARY DEPOSITS
Includes Gila Conglomerate and other stream and lake deposits mainly in intermontane areas. Consists of loosely to firmly consolidated gravel, sand, and silt, local clay, gypsum, marl, limestone, diatomite, and some intercalated basalt flows and felsic tuff beds

QTb VOLCANIC ROCKS
Basaltic flows, agglomerate, tuff, and cinders

QTi DIKES AND PLUGS
Mainly andesitic to basaltic in composition

TERTIARY — Pliocene

Tms SEDIMENTARY ROCKS
Terrestrial conglomerate, sandstone, siltstone, limestone, tuffaceous beds, and andesitic flows and breccias, including Locomotive Fanglomerate, Helmet Fanglomerate, Pantano Formation, and Whitetail conglomerate

Ts SEDIMENTARY ROCKS
Mainly conglomerate, sandstone, siltstone, limestone, and tuffaceous beds but locally includes volcanic units ranging from rhyolitic to andesitic in composition

Tv Tvs Tvi VOLCANIC ROCKS
Flows, tuffs, breccias, and agglomerates interfingering in part with Tertiary sedimentary rocks. Includes some plugs and dikes
Tv, rhyolitic to basaltic rocks
Tvs, silicic volcanic rocks
Tvi, intermediate volcanic rocks

Ti DIKES, SILLS, AND PLUGS
Rhyolitic to basaltic in composition

Tps SEDIMENTARY DEPOSITS
Fossiliferous alluvial and lacustrine deposits of middle or early Pliocene age within valle of present drainage systems and correlative conglomerate, sand, silt, and clay

CRETACEOUS & TERTIARY — Upper Cretaceous & Pre-Miocene

TKs SEDIMENTARY ROCKS
Includes Cloudburst Formation in Pinal County and unnamed shale, sandstone, conglomerate, and limestone units; locally contains volcanic rocks

TKv TKa TKr VOLCANIC ROCKS
Includes flows, pyroclastic rocks, and associated conglomerates consisting largely of volcanic debris.
TKv, andesitic to rhyolitic in composition
TKa, predominantly andesitic in composition
TKr, predominantly rhyolitic in composition

TKg TKi INTRUSIVE ROCKS
TKg, granite, quartz monzonite, granodiorite, quartz diorite, and some porphyry equivalents of these rocks
TKi, granitic, dioritic, rhyolitic, and andesitic dikes, sills, and plugs

TKsc TKgn METAMORPHIC ROCKS
TKsc, schist and phyllite
TKgn, gneiss

CRETACEOUS — Upper Cretaceous

Kus SEDIMENTARY ROCKS
Includes beds, probably equivalent to the Pinkard Formation, Graham and Pinal Counties. Upper Cretaceous beds in the Santa Rita Mountains are included with the undivided Cretaceous rocks (Ks)

Ks Kv Ka Kvs SEDIMENTARY AND VOLCANIC ROCKS
Ks, includes Amole Arkose and Recreation Red Beds and other units of known or supposed Cretaceous age
Kv, rhyolitic to andesitic flows and tuffs
Ka, predominantly andesitic flows and tuffs
Kvs, intercalated sedimentary and rhyolitic to andesitic volcanic rocks

CRETACEOUS — Lower Cretaceous

Kls SEDIMENTARY ROCKS
Includes Bisbee Group; in northern Cochise County also includes underlying Jurassic (?) or Triassic (?) volcanic rocks

Order does not reflect age

Mzgr MESOZOIC GRANITE TO QUARTZ DIORITE

Mzv MESOZOIC VOLCANIC ROCKS
Rhyolitic to andesitic flows and pyroclastic rocks; locally includes interfingering shale, sandstone, and conglomerate. Includes units known to predate Lower Cretaceous rocks in the Huachuca and Patagonia Mountains

TRIASSIC & JURASSIC

J₹g Granite, quartz monzonite, alaskite, and granitic to monzonitic porphyries

PENNSYLVANIAN & PERMIAN

PPn NACO GROUP UNDIVIDED

Pnu UPPER FORMATIONS
Includes Rainvalley Formation, Concha Limestone, and Scherrer Formation

PPnl LOWER FORMATIONS
Includes Epitaph Dolomite (Permian), Colina Limestone (Permian), Earp Formation (Permian and Upper Pennsylvanian), and Horquilla Limestone (Pennsylvanian)

Pzs PALEOZOIC SEDIMENTARY ROCKS UNDIVIDED

DEVONIAN & MISSISSIPPIAN

MDs SEDIMENTARY ROCKS
Includes Upper Mississippian Paradise Formation, Escabrosa Limestone (Upper and Lower Mississippian), Martin Formation and locally Pennsylvanian limestone

CAMBRIAN & ORDOVICIAN

O€s SEDIMENTARY ROCKS
Includes El Paso Limestone (Lower Ordovician), Abrigo Formation (Upper and Middle Cambrian), and Bolsa Quartzite (Middle Cambrian) in eastern Cochise County and Abrigo Formation and Bolsa Quartzite in western Cochise, Graham, Pima, Santa Cruz, and Pinal Counties

PRECAMBRIAN — Younger Precambrian

p€a APACHE GROUP
Includes Mescal Limestone and associated basalt flows, Dripping Spring Quartzite, and Pioneer Shale

p€db DIABASE
Locally includes post-Precambrian diabase

p€t TROY QUARTZITE
Locally may contain Cambrian sandstone and quartzite

PRECAMBRIAN — Older Precambrian

p€gr INTRUSIVE ROCKS
Granite, quartz monzonite, granodiorite, and quartz diorite. Locally includes areas of granitic rocks, and other igneous rocks of post-Paleozoic age

p€sc p€gn METAMORPHOSED SEDIMENTARY AND VOLCANIC ROCKS
Mainly phyllite, slate, mica schist, chlorite schist, and amphibolite derived from interbedded shale, sandstone, and rhyolitic to basaltic flows and tuffs but locally includes intrusive rhyolite, diorite, gabbro, and pyroxenite
p€sc, Pinal Schist and other schistose units
p€gn, gneiss: includes some areas of undivided schist and granite

DEPTH TO WATER, 1970
SANTA CRUZ - SAN PEDRO RIVER BASINS
ARIZONA

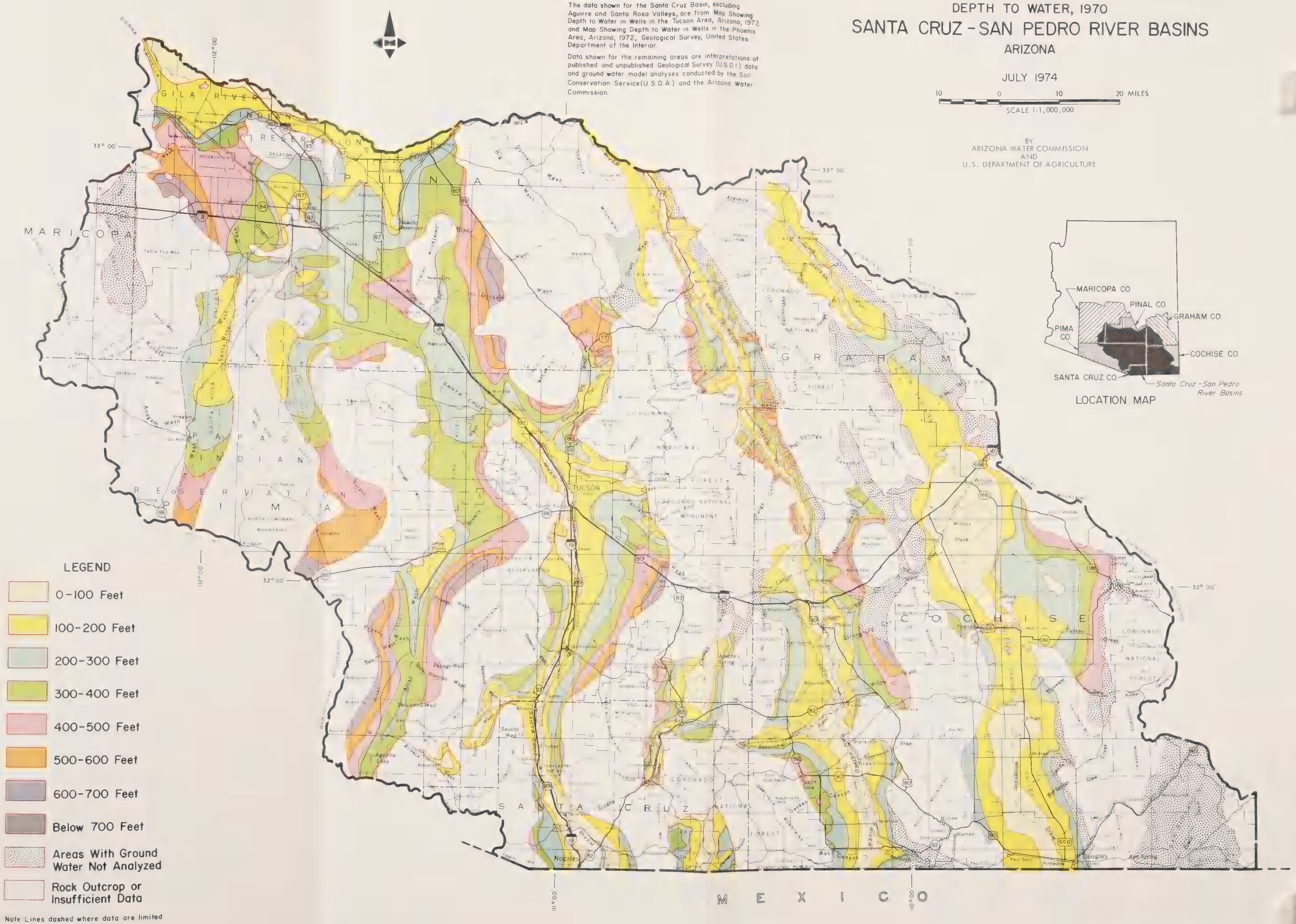
JULY 1974

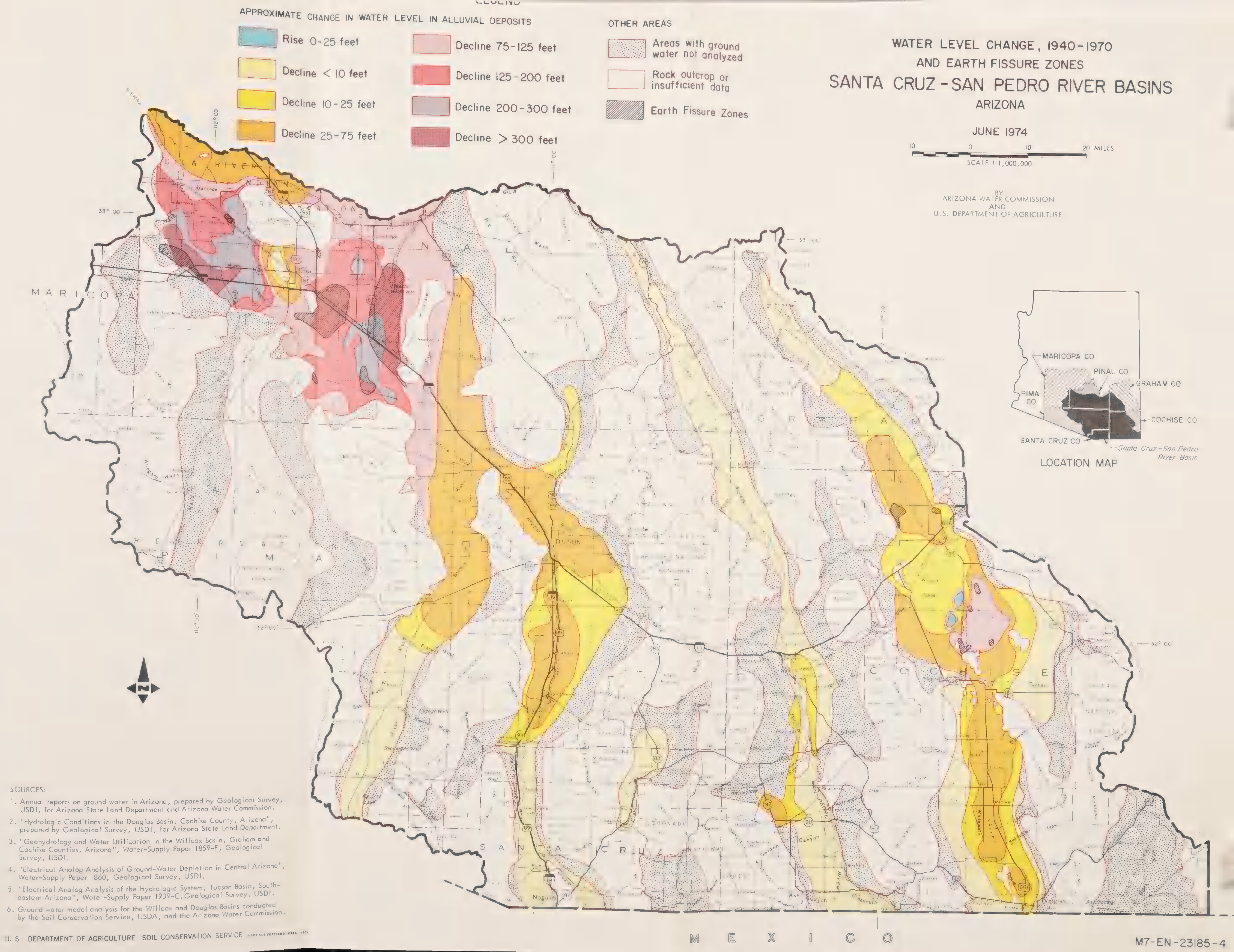
SCALE 1:1,000,000

BY
ARIZONA WATER COMMISSION
AND
U.S. DEPARTMENT OF AGRICULTURE

Sources:
The data shown for the Santa Cruz Basin, excluding Aguirre and Santa Rosa Valleys, are from Map Showing Depth to Water in Wells in the Tucson Area, Arizona, 1972 and Map Showing Depth to Water in Wells in the Phoenix Area, Arizona, 1972, Geological Survey, United States Department of the Interior.

Data shown for the remaining areas are interpretations of published and unpublished Geological Survey (U.S.D.I.) data and ground water model analyses conducted by the Soil Conservation Service (U.S.D.A.) and the Arizona Water Commission.




WATER LEVEL CHANGE, 1940-1970
AND EARTH FISSURE ZONES
SANTA CRUZ - SAN PEDRO RIVER BASINS
ARIZONA
JUNE 1974
10 0 10 20 MILES
SCALE 1:1,000,000
BY
ARIZONA WATER COMMISSION
AND
U.S. DEPARTMENT OF AGRICULTURE
LEGEND
APPROXIMATE CHANGE IN WATER LEVEL IN ALLUVIAL DEPOSITS
Rise 0-25 feet
Decline < 10 feet
Decline 10-25 feet
Decline 25-75 feet
Decline 75-125 feet
Decline 125-200 feet
Decline 200-300 feet
Decline > 300 feet
OTHER AREAS
Areas with ground water not analyzed
Rock outcrop or insufficient data
Earth Fissure Zones
MARICOPA CO.
PINAL CO
GRAHAM CO
PIMA CO
COCHISE CO
SANTA CRUZ CO.
Santa Cruz - San Pedro River Basin
LOCATION MAP
MARICOPA
PINAL
GRAHAM
COCHISE
PIMA
SANTA CRUZ
GILA RIVER INDIAN RESERVATION
PAPAGO INDIAN RESERVATION
TUCSON
CORONADO
NATIONAL
MEXICO
33° 00'
32° 00'
112° 00'
111° 00'
SOURCES:
1. Annual reports on ground water in Arizona, prepared by Geological Survey, USDI, for Arizona State Land Department and Arizona Water Commission.
2. "Hydrologic Conditions in the Douglas Basin, Cochise County, Arizona", prepared by Geological Survey, USDI, for Arizona State Land Department.
3. "Geohydrology and Water Utilization in the Willcox Basin, Graham and Cochise Counties, Arizona", Water-Supply Paper 1859-F, Geological Survey, USDI.
4. "Electrical Analog Analysis of Ground-Water Depletion in Central Arizona", Water-Supply Paper 1860, Geological Survey, USDI.
5. "Electrical Analog Analysis of the Hydrologic System, Tucson Basin, Southeastern Arizona", Water-Supply Paper 1939-C, Geological Survey, USDI.
6. Ground water model analysis for the Willcox and Douglas Basins conducted by the Soil Conservation Service, USDA, and the Arizona Water Commission.
U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE
M7-EN-23185-4

WELL WATER QUALITY FOR DOMESTIC USE

SANTA CRUZ - SAN PEDRO RIVER BASINS

ARIZONA

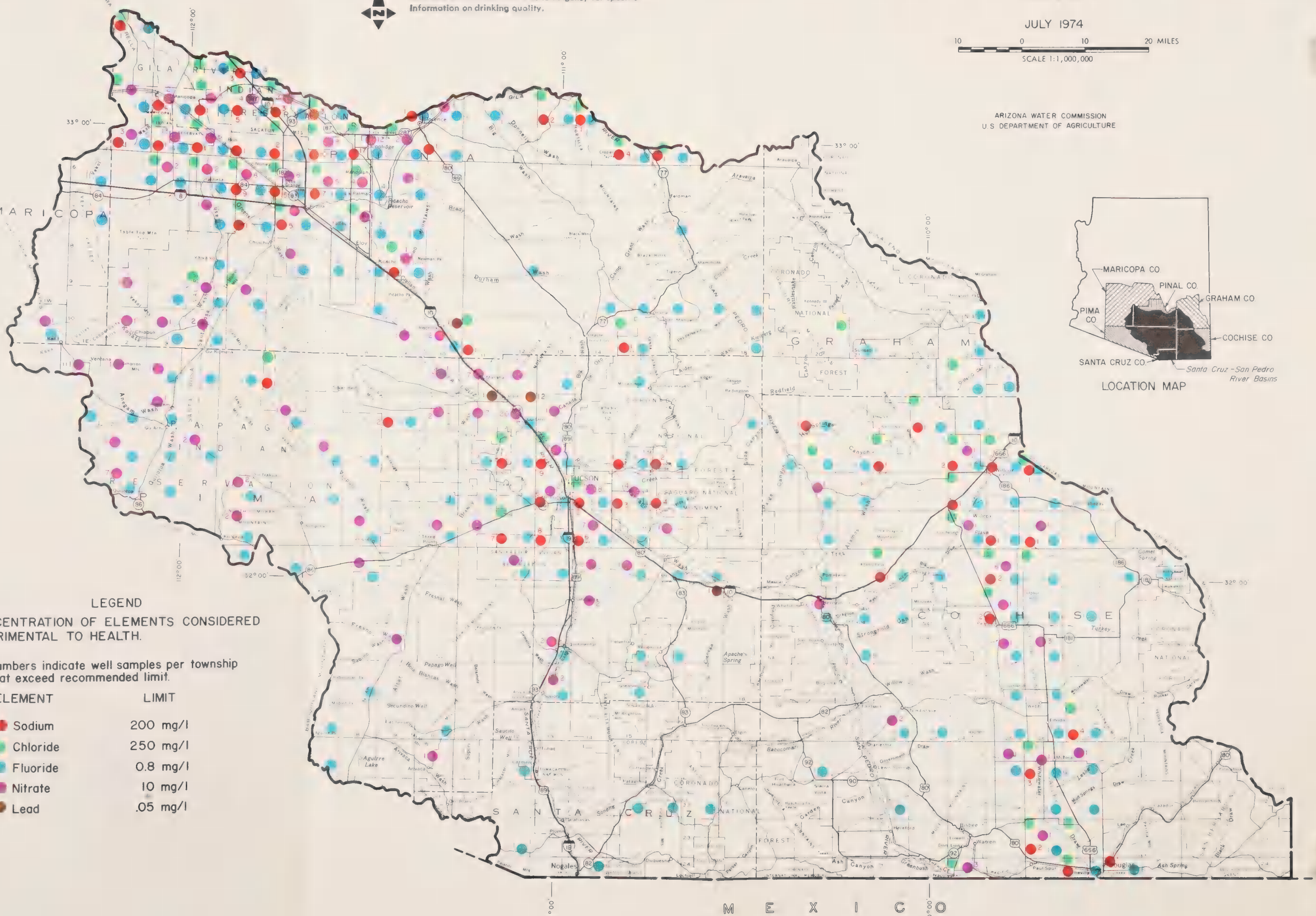
JULY 1974

10 0 10 20 MILES

SCALE 1:1,000,000

ARIZONA WATER COMMISSION
U.S. DEPARTMENT OF AGRICULTURE

NOTE: This [illegible] is included for general information purposes only. Refer [illegible] the Arizona State Department of Health Services and U.S. Environmental Protection Agency for specific information on drinking quality.



LEGEND

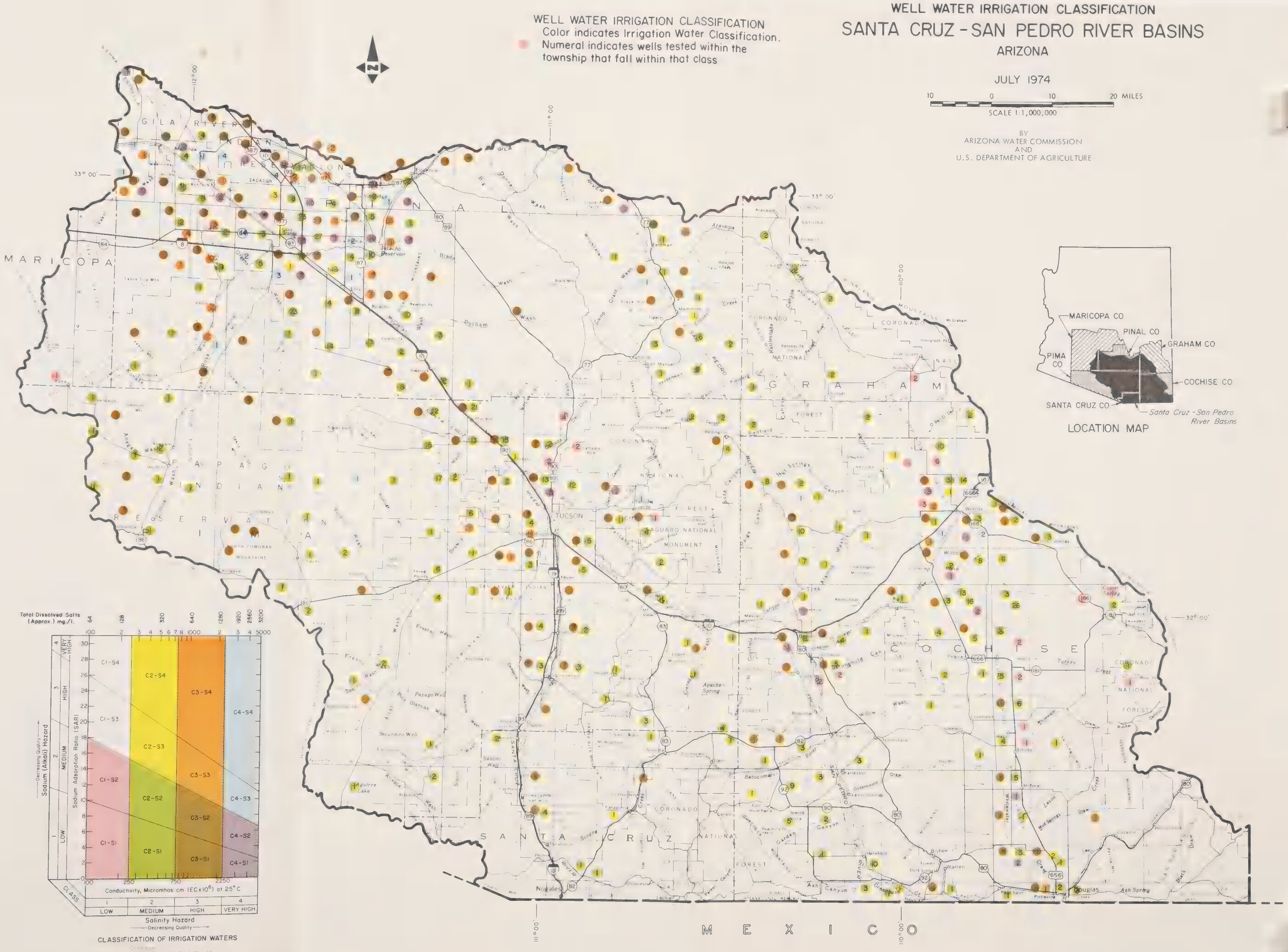
CONCENTRATION OF ELEMENTS CONSIDERED DETRIMENTAL TO HEALTH.

Numbers indicate well samples per township that exceed recommended limit.

ELEMENT	LIMIT
6 Sodium	200 mg/l
Chloride	250 mg/l
Fluoride	0.8 mg/l
4 Nitrate	10 mg/l
5 Lead	.05 mg/l

U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE

M7-EN-23185-7


WELL WATER IRRIGATION CLASSIFICATION
SANTA CRUZ - SAN PEDRO RIVER BASINS
ARIZONA
JULY 1974
10 0 10 20 MILES
SCALE 1:1,000,000
BY
ARIZONA WATER COMMISSION
AND
U.S. DEPARTMENT OF AGRICULTURE
WELL WATER IRRIGATION CLASSIFICATION
Color indicates Irrigation Water Classification.
Numeral indicates wells tested within the township that fall within that class
MARICOPA CO
PINAL CO
GRAHAM CO
PIMA CO
COCHISE CO
SANTA CRUZ CO
Santa Cruz - San Pedro River Basins
LOCATION MAP
MARICOPA
PINAL
GRAHAM
COCHISE
SANTA CRUZ
PAPAGO INDIAN RESERVATION
GILA RIVER INDIAN RESERVATION
TUCSON
Nogales
Douglas
MEXICO
CLASSIFICATION OF IRRIGATION WATERS
Total Dissolved Salts (Approx.) mg./l.
Sodium Adsorption Ratio (SAR)
Sodium (Alkali) Hazard
Decreasing Quality
Conductivity, Micromhos cm (EC x 10⁶) at 25° C
Salinity Hazard
Decreasing Quality
LOW MEDIUM HIGH VERY HIGH
C1-S4 C2-S4 C3-S4 C4-S4
C1-S3 C2-S3 C3-S3 C4-S3
C1-S2 C2-S2 C3-S2 C4-S2
C1-S1 C2-S1 C3-S1 C4-S1

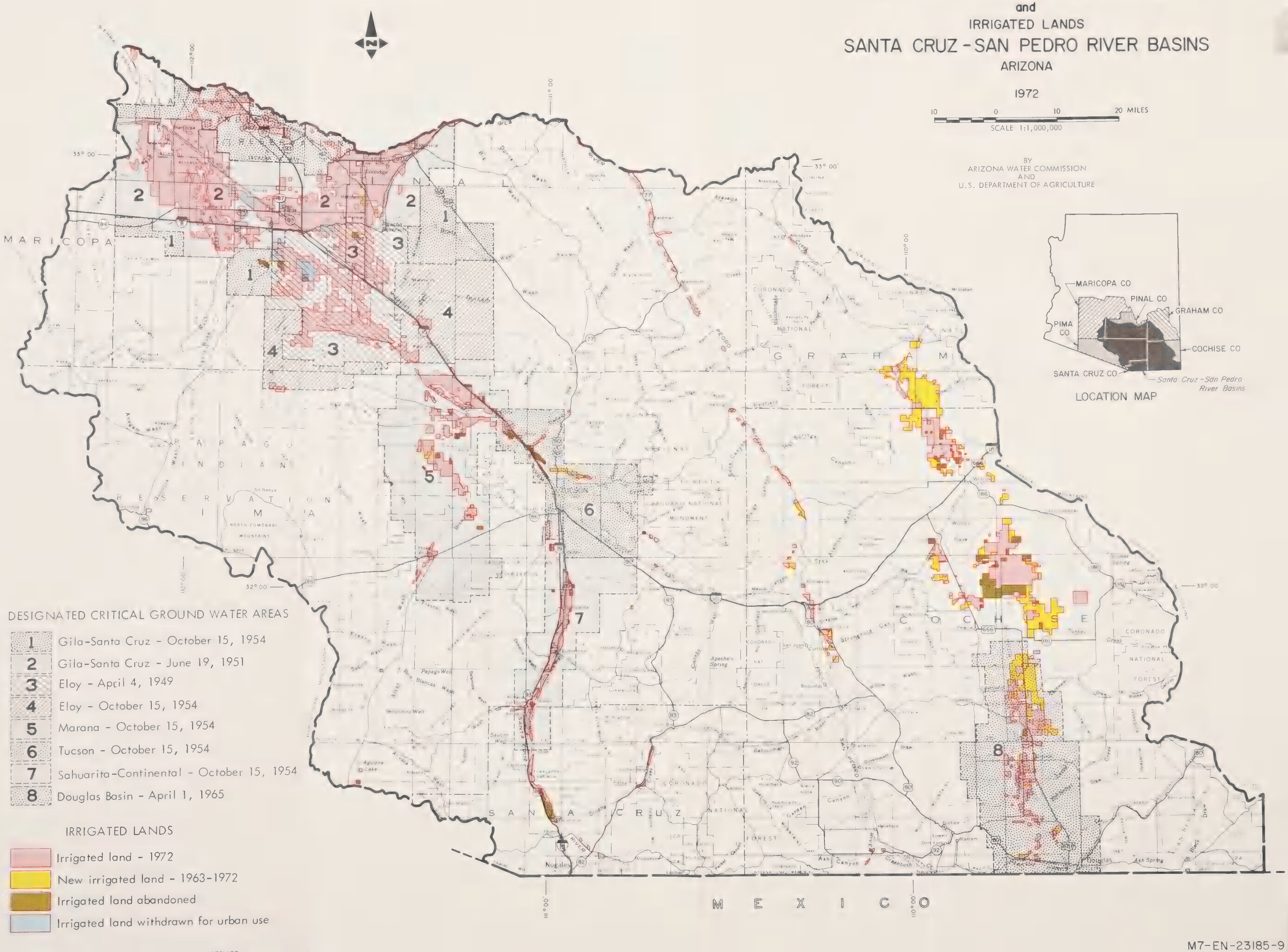
DESIGNATED CRITICAL GROUND WATER AREAS and IRRIGATED LANDS

SANTA CRUZ - SAN PEDRO RIVER BASINS

ARIZONA

1972

BY
ARIZONA WATER COMMISSION
AND
U.S. DEPARTMENT OF AGRICULTURE



U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE

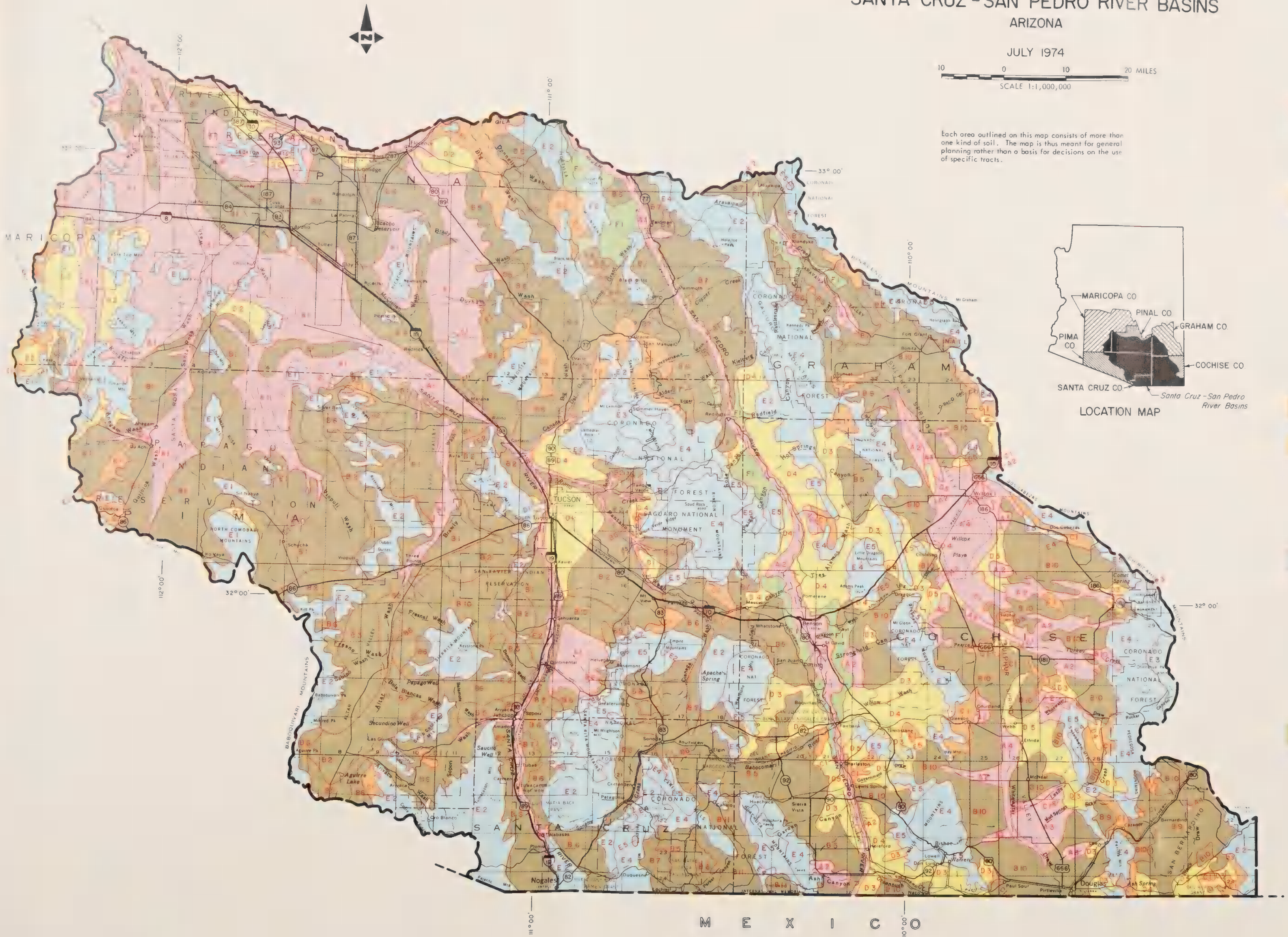
M7-EN-23185-9

GENERAL SOIL MAP

SANTA CRUZ - SAN PEDRO RIVER BASINS

ARIZONA

JULY 1974



Each area outlined on this map consists of more than one kind of soil. The map is thus meant for general planning rather than a basis for decisions on the use of specific tracts.

LOCATION MAP

LEGEND

SOILS OF THE RIVER BOTTOMS AND ALLUVIAL FANS

A1 GILMAN-ANTHO PIMER ASSOCIATION: Deep, loamy soils, 0 to 3 percent slopes. Vegetation is dominantly desert brush, cacti and annual grass.

A2 COMORO-ANTHONY-GRABE ASSOCIATION: Deep, loamy soils, 0 to 3 percent slopes. Vegetation is dominantly brush and grass.

A3 GUEST ASSOCIATION: Deep, clayey soils, 0 to 1 percent slopes. Vegetation is dominantly grass.

A4 GOTHARD-CROT-STEWART ASSOCIATION: Shallow and deep, loamy, saline-alkali soils with areas of silica-lime cemented hardpans at shallow and very shallow depths. 0 to 1 percent slopes. Vegetation is dominantly grass.

SOILS OF THE VALLEY SLOPES

B1 MOHALL-CASA GRANDE-ANTHO ASSOCIATION: Deep, loamy soils with some depressional areas of saline-alkali soils. 0 to 2 percent slopes. Vegetation is dominantly desert brush, cacti and annual grass.

B2 MOHAVE-PINALENO-LATENE ASSOCIATION: Deep, loamy and gravelly loamy soils. 0 to 5 percent slopes. Vegetation is dominantly brush and grass.

B3 CASA GRANDE-LA PALMA: Deep and moderately deep, loamy, saline-alkali soils, some of which have lime-silica cemented hardpans. 0 to 2 percent slopes. Vegetation is dominantly desert brush, cacti and annual grass.

B4 MOHALL-VECONT ASSOCIATION: Deep, loamy soils and deep clayey soils, 0 to 2 percent slopes. Vegetation is dominantly desert brush, cacti and annual grass.

B5 WHITE HOUSE-BERNARDINO ASSOCIATION: Deep, clayey soils, 2 to 8 percent slopes. Vegetation is dominantly brush and grass.

B6 CARALAMPI-WHITE HOUSE ASSOCIATION: Deep, gravelly loamy and clayey soils, 5 to 30 percent slopes. Vegetation is dominantly brush and grass.

B7 CARALAMPI ASSOCIATION: Deep, gravelly loamy soils, 30 to 60 percent slopes. Vegetation is dominantly brush and grass.

B8 BONITA-SONTAG ASSOCIATION: Deep, cobbly and gravelly, clayey soils on basalt, cinders, or ash. 0 to 25 percent slopes. Vegetation is dominantly grass.

B10 CONTINENTAL-TUBAC ASSOCIATION: Deep, clayey soils with some areas of loamy and gravelly soils. 0 to 30 percent slopes. Vegetation is dominantly grass.

B11 CASTO-MARTINEZ ASSOCIATION: Deep, clayey soils and gravelly loamy soils. 0 to 40 percent slopes. Vegetation is dominantly oak and grass.

SHALLOW UPLAND SOILS OVER BEDROCK

C1 CELLAR-GRAHAM-CHERIONI ASSOCIATION Very shallow and shallow, cobbly and gravelly, loamy, and clayey soils on bedrock. 5 to 30 percent slopes. Vegetation is dominantly grass and brush.

LIMY SOILS ON VALLEY SLOPES AND HIGH FANS

D1 RILLINO-CAVE ASSOCIATION: Deep, gravelly loamy soils, and shallow gravelly loamy soils over lime cemented hardpans. 2 to 15 percent slopes. Vegetation is dominantly desert brush.

D2 LAVEEN-RILLITO ASSOCIATION: Deep, loamy soils and gravelly loamy soils. 0 to 3 percent slopes. Vegetation is dominantly desert brush, cacti and annual grass.

D3 KIMBROUGH-CAVE ASSOCIATION: Very shallow and shallow, gravelly loamy soils over lime cemented hardpans. 0 to 25 percent slopes. Vegetation is dominantly grass and brush

D4 HATHAWAY-NICKEL ASSOCIATION: Deep, gravelly and very gravelly loamy soils. 0 to 30 percent slopes. Vegetation is dominantly grass and brush.

D5 ELFRIDA-KARRO ASSOCIATION: Deep, loamy soils. 0 to 15 percent slopes. Vegetation is dominantly grass and brush.

SOILS OF THE MOUNTAINS

E1 ROCK OUTCROP-CHERIONI-GACHADO ASSOCIATION: Mountains and buttes with rock outcrop and very shallow and shallow sandy and loamy soils that are gravelly, cobbly and stony. 5 to 75 percent slopes. Vegetation is dominantly desert brush, cacti and annual grass.

E2 LAMPSHIRE-GRAHAM-ROCK OUTCROP ASSOCIATION: Mountains and buttes with very shallow and shallow soils that are gravelly, cobbly and stony and large areas of rock outcrop. 5 to 75 percent slopes. Vegetation is dominantly brush and grass with oak, pinon pine and juniper at the higher elevations.

E3 MIRABAL-BARKERVILLE-ROCK OUTCROP ASSOCIATION: High mountains with shallow, gravelly and cobbly soils and large areas of rock outcrop. 5 to 75 percent slopes. Vegetation is dominantly mixed conifers.

E4 FARAWAY-BARKERVILLE-ROCK OUTCROP ASSOCIATION: Mountainous areas with very shallow and shallow, gravelly and cobbly soils and large areas of rock outcrop. 5 to 75 percent slopes. Vegetation is dominantly oak, juniper, and grass with pine at the higher elevations above 6200 feet.

E5 TORTUGAS-ROCK OUTCROP ASSOCIATION: Very shallow and shallow very cobbly and gravelly loamy soils and rock outcrop. 30 to 60 percent slopes. Vegetation is dominantly oak, juniper and grass with pine at the higher elevations above 6200 feet.

ERODED LANDS

F1 ERODED AND GULLIED CALCIORTHIDS ASSOCIATION: Deeply dissected, gravelly and very gravelly loamy and sandy soils and soil materials. 15 to 60 percent slopes. Vegetation is brush with some grass.

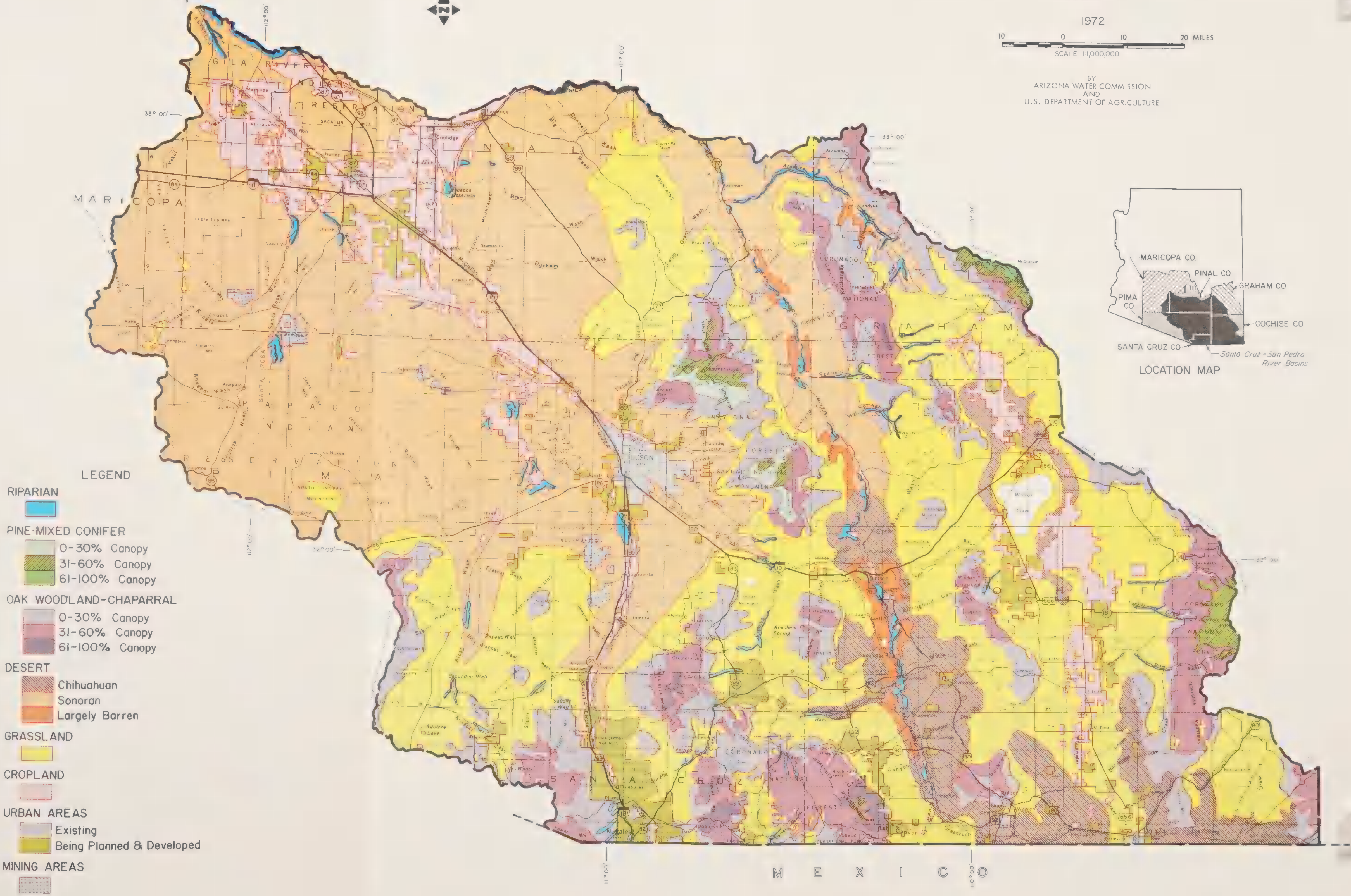
U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE

VEGETATION, CROPLANDS, URBAN & MINING AREAS

SANTA CRUZ - SAN PEDRO RIVER BASINS

ARIZONA

1972



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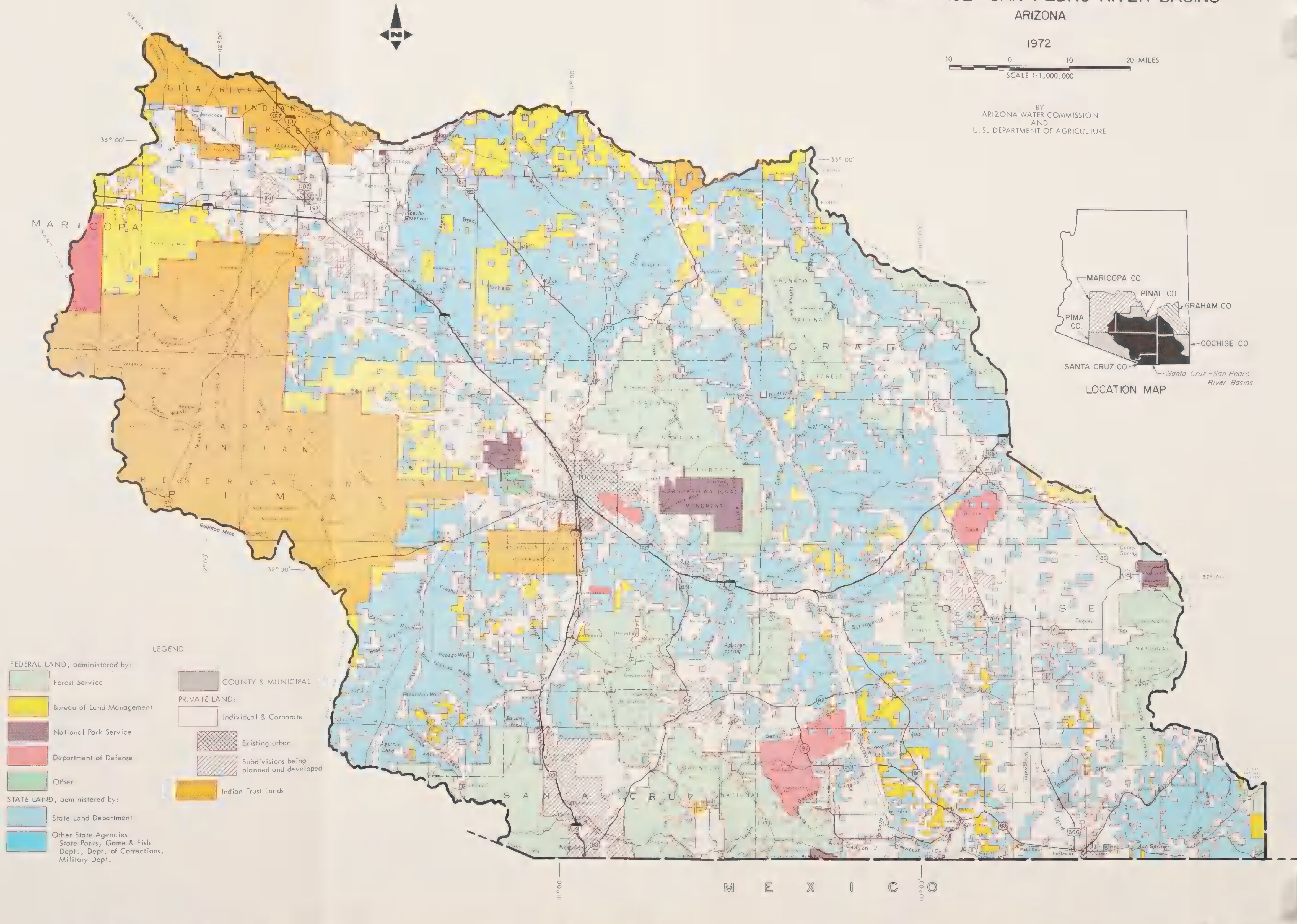
LAND OWNERSHIP AND ADMINISTRATION
SANTA CRUZ - SAN PEDRO RIVER BASINS
ARIZONA

1972

BY
ARIZONA WATER COMMISSION
AND
U.S. DEPARTMENT OF AGRICULTURE



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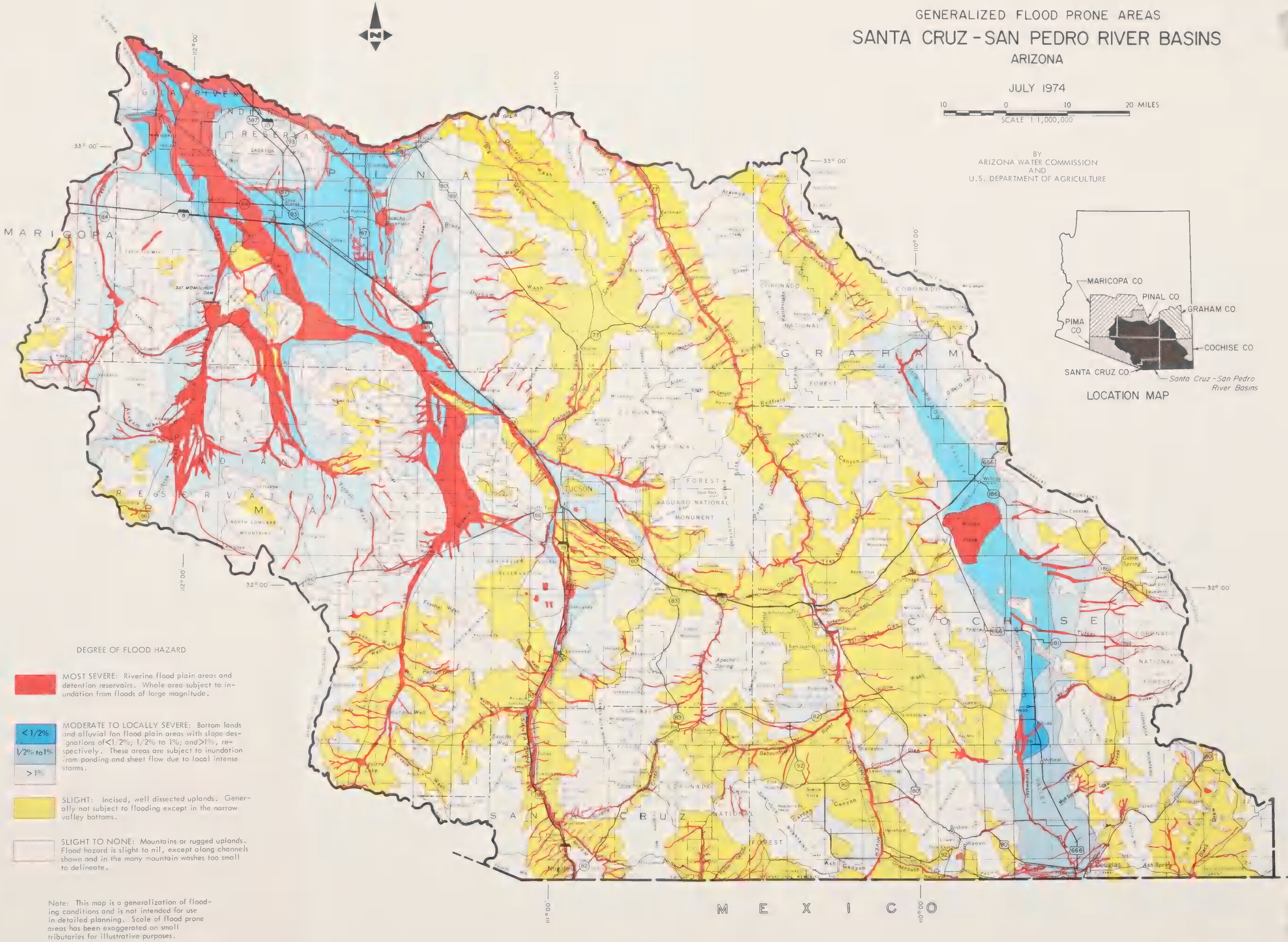

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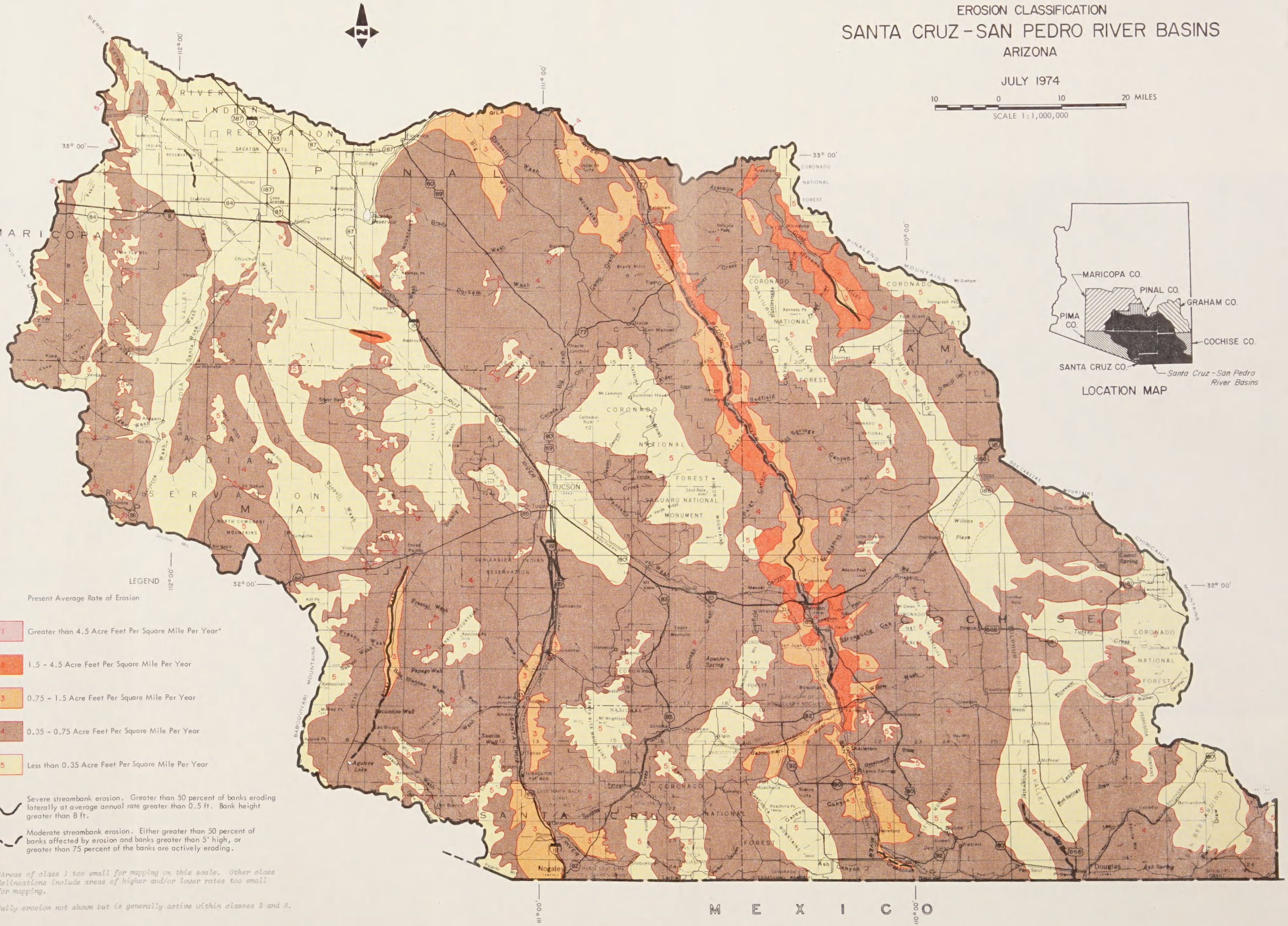
EROSION CLASSIFICATION
SANTA CRUZ - SAN PEDRO RIVER BASINS
ARIZONA

JULY 1974

10 0 10 20 MILES
SCALE 1:1,000,000



LOCATION MAP

LEGEND

Present Average Rate of Erosion

1	Greater than 4.5 Acre Feet Per Square Mile Per Year*
2	1.5 - 4.5 Acre Feet Per Square Mile Per Year
3	0.75 - 1.5 Acre Feet Per Square Mile Per Year
4	0.35 - 0.75 Acre Feet Per Square Mile Per Year
5	Less than 0.35 Acre Feet Per Square Mile Per Year

Severe streambank erosion. Greater than 50 percent of banks eroding laterally at average annual rate greater than 0.5 ft. Bank height greater than 8 ft.

Moderate streambank erosion. Either greater than 50 percent of banks affected by erosion and banks greater than 5' high, or greater than 75 percent of the banks are actively eroding.

*Areas of class 1 too small for mapping on this scale. Other class delineations include areas of higher and/or lower rates too small for mapping.

Gully erosion not shown but is generally active within classes 2 and 3.

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